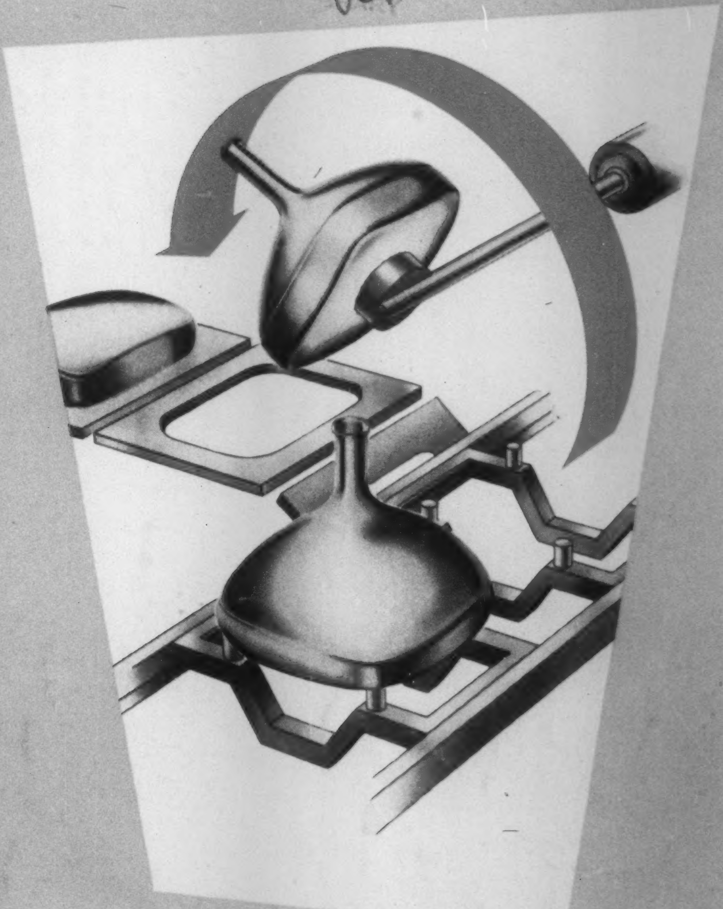
UNIVERSITY OF MICHIGAN

AUTOMATION

OCTOBER 1955



AUTOMATION TODAY

Aluminizing TV Tubes

The Magazine of Automatic Operations

- **Producing Aerosols**
- **Heating and Coating Billets for Extrusion**
- **Automatic Detection of Dull Drills**
- **Punched Card Machine Tool Control**

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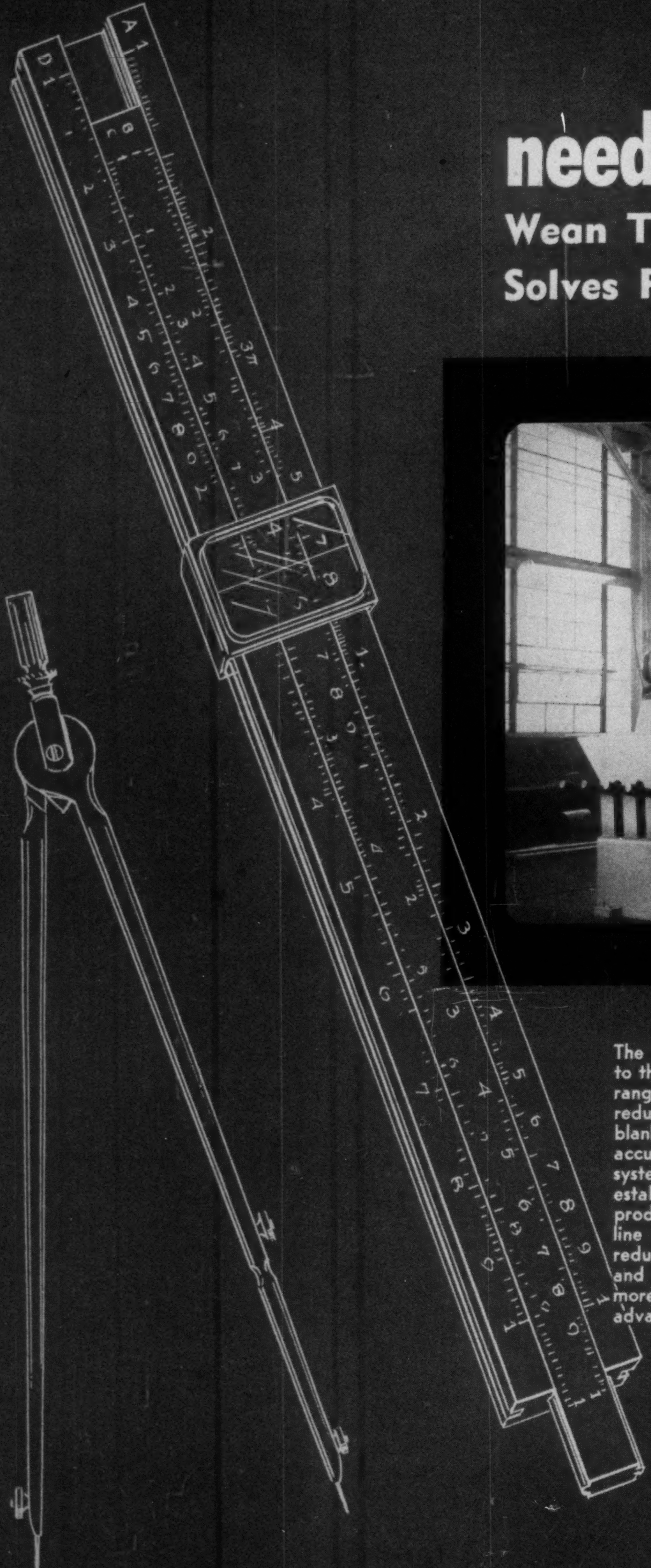
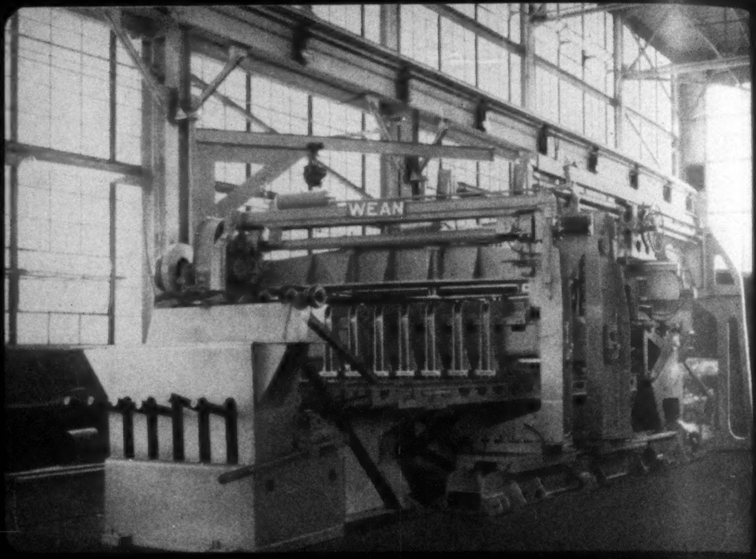


need an idea?

Wean Trapezoidal Shear Line Solves Problem for Auto Maker



The Wean Trapezoidal Shear Line was developed as an answer to the high speed blanking of irregularly shaped pieces in the broad range that can be described as trapezoids or parallelograms. This us reduces tremendously the cost of expensive die setup in major blanking presses. Two pieces are made at each index with the accuracy that can only be achieved by a measured length indexing system. The cut can range from 45° to 90° angles. The latter settin establishes the line as a straight cut-up unit with twice the normal production of conventional shear lines. At Wean, we consider this line as another important step forward in our policy of cost reduction through progressive engineering. People in the automotive and metal fabricating fields have come to look more and more toward Wean Equipment for spectacular advances in machinery for metal processing.

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OCTOBER, 1955
Vol. 2—No. 10

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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automation outlook

CHALLENGE TO MANAGEMENT

". . . the impact of automation on business enterprise leads us to the conclusion that we need much greater conceptual skill in management. We need management that can manage by system, knowledge and method, that can analyze the objectives of the business, think through the assumptions on which it bases its policies, weigh the risks and decide between alternative courses of action on a rational basis. We need management that can operate rationally, systematically and with a general knowledge of systematic theory. The intuitive manager alone will not be able to manage. . . "—*Peter F. Drucker, professor of management, New York University. See Page* 100.

THE OBVIOUS ANSWER

". . . side by side you have two factories making buttonhooks. The management of factory *A* uses hand labor to the greatest extent possible. The management of factory *B* automates his entire plant. *B* can now turn out 10 times the number of buttonhooks that *A* can with one tenth the number of employees. Should he pay his employees 100 times—or even 10 times—what the employees of factory *A* are paid? This may sound like a silly question, but this, in principle, is what is being urged by those who advocate increasing wages on the basis of increased productivity, rather than cutting the price of buttonhooks so that everyone can afford a buttonhook in every room. But what happened to the employees who were left unemployed by the automation of plant *B*? The obvious answer is that they went down the street and are now working overtime at the zipper factory which is going to put both of the buttonhook factories out of business anyway . . ."—*Dr. W. R. G. Baker, vice president and general manager, Electronics Div., General Electric Co.*

WITH GAGING IN MIND

". . . what about tomorrow's automatic gage? Where are we going from here? It is certain that we will be seeing more automatic gaging in the future. The automatic gage will take over more functions from the operator and inspector. It is not too much to expect that machine tools will be designed with the gaging in mind at the time of the design . . ."—*A. Wiseman, chief electrical engineer, The Sheffield Corp., Dayton, Ohio.*

WHOLE NEW PHILOSOPHY

". . . I don't mean that our factories had no automatic machines. In one sense we were too automatic—we had too many unrelated machines. We found, for example, that it was fast becoming impossible to utilize the full capacity of up-to-date machine tools, because men couldn't load and unload them fast enough by hand. The trouble with our manufacturing methods was that, like Topsy, they "just grew", and nobody had taken time out for a long view. What we needed was a complete rethinking of the problem—a whole new philosophy of manufacturing . . . In place of the old, complicated maze of machinery, we visualized long, clean production lines along which our parts and materials would flow evenly and smoothly—just as fast as modern machine tools could handle them. The processes of automatic lubrication, scrap removal and, to some extent, quality testing would be integrated into the lines. The new lines would be equipped with various control devices to assure effective preventive maintenance. The achievement of that dream over the span of a few short years involved a lot of work and headaches . . . we had to fit together the products of dozens of different manufacturers into a smooth-running system. The result was what has come to be called Automation . . ."—*R. H. Sullivan, vice president and group executive, Ford Motor Company.*

AUTOMATION

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BPA

(Advertisement)

MISSILE TEST EQUIPMENT For over ten years Farnsworth has participated in the design, development, and production of guidance and control systems and special test equipment for such missile programs as Terrier, Talos, Sparrow, and others. Numerous "firsts" in this field have been accomplished as a result of contributions in the form of missile receivers, control systems, power supplies and complete system analyses.

INDUSTRIAL TELEVISION Standard model 600A is the result of Farnsworth's more than 30 years experience in the design and production of complex military and industrial equipment—engineered especially for industrial, educational and business use.

IMAGE CONVERTER TUBES Used in any application where it is necessary or desirable to "see in the dark." Convert an infrared image into a visible image. Applications: medical and biological research, hot-body observation, temperature distribution, crime detection, security, and photography.

INFRARED VIEWER This unique, compact, easy to handle viewer is a valuable tool for crime detection, research and industrial application. Observation of objects or scenes in the dark is easily accomplished when they are illuminated by infrared radiation.

PHOTOMULTIPLIER TUBES Responsive in the near infrared spectrum featuring sensitivities as high as 50 amperes per lumen of incident radiation. Applications include photometric measurements for industrial and scientific uses.

IMAGE DISSECTOR A highly versatile TV camera tube particularly well adapted for use as a slide or facsimile scanner. This tube can be constructed in a variety of types to meet special requirements.

RADAR RANGE CALIBRATOR, AN/UPM-11A A precision instrument incorporating both "Radar" and "Beacon" functions. The equipment operates as a radar transponder in that pulsed r-f energy fed into the equipment results in a series of return echo pulses being fed back from the equipment to the radar under calibration. This simulates radar targets at accurately determined ranges.

PORTABLE CABLE TESTER Designed for testing all radio frequency cables that will accommodate, or can be adapted to, type "HN", "N", or "BNC" connectors. It will supply a d-c voltage up to 12,000 volts provided the current drain is negligible, and current surges of at least 3,000 amperes peak into a load of 0.05 ohm at room temperature.

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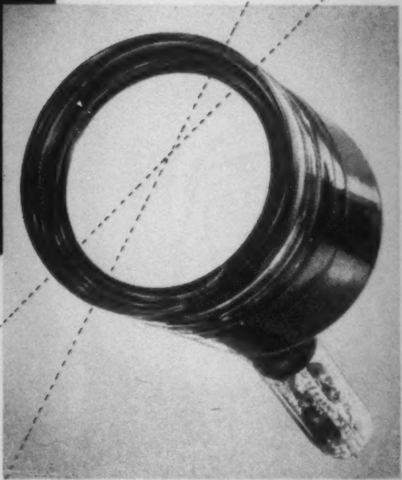
SUN-LIKE BRILLIANCE AND MEMORY, TOO!



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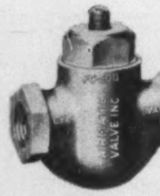

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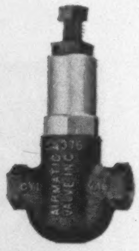
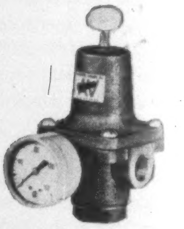


SEQUENCE VALVES



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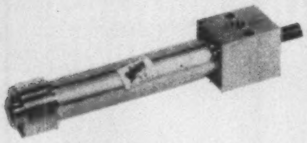
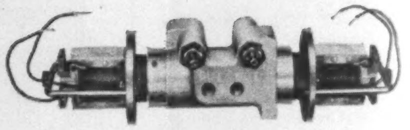


CYLINDERS



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• In this pushbutton age, no circuit is complete without proper control. And when air control valves are needed, AIRMATIC is your best bet.

The widespread use of AIRMATIC VALVES is convincing proof that they are outstanding and dependable and accepted by the most critical engineers.

AIRMATIC VALVES are easy to operate, yet are compactly designed and have an inherent ruggedness to withstand grueling operating cycles.

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. . . about punched cards

Collecting market data on punched cards is not unusual today.

Using these cards as we do to match industrial publication coverage to the number of worthwhile establishments *is* unusual.

Reporting coverage figures to advertisers on the Standard Industrial Classification* (S.I.C.) basis was distinctly a PENTON development. We are glad to see that more and more publishers are swinging over to this modern method of circulation analysis.

Plant counts will some day be required from all industrial publishers. Many progressive media buyers request them now. Without this information the advertiser is "flying blind" because he has no means of checking the number of worthwhile units covered (or missed) by a business magazine.

When you're using a PENTON publication you know how many worthwhile *units* are reached. Coverage reported on the S.I.C. basis enables you to measure it in relation to the total number of units. You can evaluate the proportion of the market buying power you are reaching, because information on size or type of establishments is also reported.

The ability to buy coverage in this modern way is just one of the extra values you get *when it's a PENTON publication.*

---

*All manufacturers use this system in reporting to the U. S. Bureau of the Census.

. . . but there is about the way PENTON uses them

FOUNDRY
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AUTOMATION
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AUTOMATION news

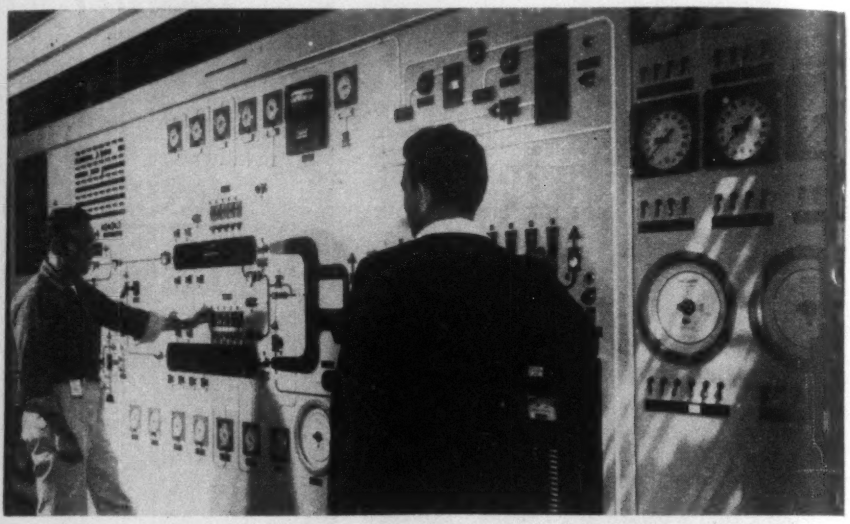
Today's events and developments in the field of automation

Ramjet Tests Require Automatic Recording of Data

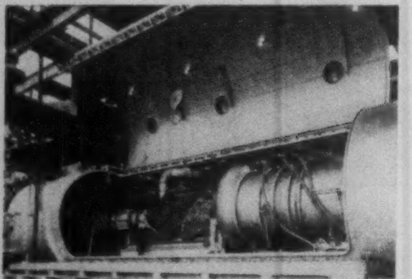
AUTOMATIC recording of performance data is a "must" in equipment tests involving short periods of time but extensive preparation. Ramjet testing facilities of Curtiss-Wright Corp. exemplify this need for automatic recording. In simulating high speeds and altitudes needed for ramjet testing, a series of steam ejectors are used to exhaust a large test chamber. An idea of the size of the operation is revealed by the rate of steam flow—2.1 million pounds per hour for high air flows. In blow-down operations where maximum air flows are obtained, test duration is in the order of 60 seconds. Control equipment for air flows, steam and cooling system provide for presetting command signals for this type of test.

Because of the need for obtaining the greatest number of observations possible during the short testing cycle of a ramjet, a great deal of the instrumentation is automatic and of the single-channel variety. One battery of recorders, for example, reads a total of 40 different temperatures within 20 seconds. Their recordings come both in written form and as punched cards that can be run directly into digital computers for data reduction. The method of punching cards directly is a Curtiss-Wright development. Another group of recorders takes approximately 30 different pressures in two seconds. Fuel flow records, similarly, are available both in printed and punched form. A run of cards yields a log sheet of the test and a comprehensive calculation of performance data that would take hundreds of man hours to make by ordinary methods.

An automatic camera pictures 120 separate pressure readings at a single exposure and returns a separate reading each time the shutter opens. Electronic gages measure the thrust developed by any engine or burner rig. Tape recorders have been installed to preserve all verbal orders and observations.



CONTROL panel for new Curtiss-Wright Corp. ramjet laboratory contains many automatic recording devices because of the peculiarity of tests conducted. Certain tests simulating high speeds at high altitudes take place in a matter of seconds. Performance data is automatically collected by recording instruments, directly on punched cards, by motion pictures; verbal orders and observations are preserved by magnetic tape recorders.



TESTING of ramjet engines occurs in large tank 14 feet in diameter and 98 feet long. Water jacketed to silence noise and insulate 3500F combustion temperature, the test chamber is mounted on coil springs anchored to concrete footing.

Sorter Aids File Clerks

HIGH speed electronic media sorter that operates from a standard typewriter keyboard and is capable of handling original forms in various weights and sizes is distributed by Underwood Corp. Unlike conventional punched card sorting equipment, the new machine sorts directly such original media as sales checks, bank checks, tax bills and job tickets.

The operator simply glances at

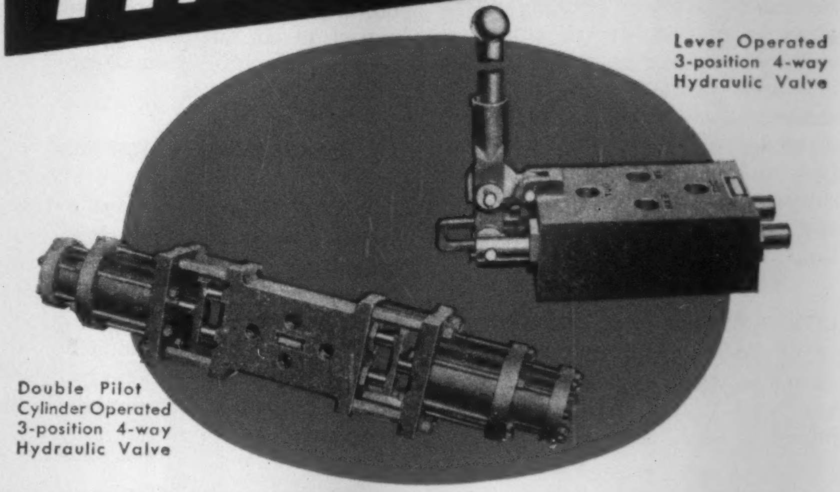
the top copy of a pile of documents to determine the alphabetical or numerical classification. As the proper typewriter keys are depressed the media are whisked to the appropriate bins. Less than a third of a second is required for the complete cycle. Electronic controls select the proper letter or number bins automatically, stacking the original forms in neat piles ready for any subsequent routine operation.

CHAIRMAN of the board of directors of Ampex Corp., **Alexander M. Poniatoff,** has announced that **Robert Sackman,** manager of the instrumentation division, has been elected an officer of the company. Sackman's division develops, engineers and markets magnetic recording equipment for such diverse uses as scientific data recording, missile test instrumentation and industrial and business data storage. Prior to assuming his new duties, Sackman was manager of Ampex's Washington, D. C., district office. He joined Ampex in 1953, after serving as the chief of a government research and development group with the Department of Defense.

New Variable Speed AC Motor to be Introduced

NEW type of variable speed ac motor will be manufactured and made available in the United States by Bogue Electric Mfg. Co. it has been announced by **E. P. Schinman,** president. "Predecessors of the Bogue N-S variable speed ac motor had been experimented with in Europe before World War II," Mr. Schinman said. "It was further refined in England by the well

Quick-As-Wink®
HYDRAULIC VALVES



Hand and Pilot-operated Types for
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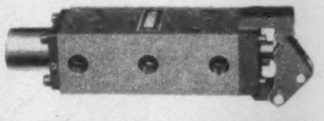
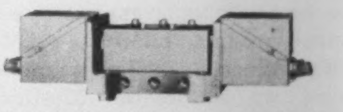
- Quick-As-Wink Hydraulic Control Valves meet the most exacting requirements. These valves are fully balanced in any position. Patented design includes hydraulically balanced U-packers. Packers are floated while crossing the valving ports, thus assuring long life, and expanded by internal valve pressure to provide a tight seal. Maintenance is extremely low and usually can be done quickly in the field, avoiding the delay of returning valves to the factory for servicing, or the need of maintaining large standby inventories. For long, dependable, trouble-free service, specify Quick-As-Wink Hydraulic Valves. Write for Bulletin No. 531 and the fully descriptive Data Sheets. They give complete details. Write *today!*

Ask us also about . . .



CAM OPERATED SINGLE PLUNGER VALVE 3/8" to 3/4" sizes. Operated by rotating cam or land on reciprocating device.



DOUBLE SOLENOID "O-TYPE" VALVE for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

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AIR AND HYDRAULIC
Control Valves
Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated
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known firm of Laurence, Scott & Electromotors, Ltd., under whose license Bogue is now producing its motor. Now for the first time in this country, these motors are available to meet the need for adjustable speed ac motors for driving machine tools; textile, paper, glass, cable and wire making machinery; printing machinery, rubber and plastics processing machines, rolling mills and extrusion machines, elevators and conveyors, fans and blowers, centrifugal and reciprocating pumps, compressors, and thousands of similar applications.

COMPLETION of Mathews Conveyer Co.'s recent expansion plan coincides with the company's 50th anniversary in the mechanized handling field. The company engineers and manufactures power, gravity and special conveying machinery for every type of industry. **Odd H. McCleary,** vice president and general manager of the Ellwood plant, stated that the new facilities recently added had become necessary if the company were to meet the tremendous demand for conveying equipment. Begun 18 months ago, the million dollar expansion program has resulted in an increase of 30 per cent in manufacturing area.

TV Broadcasting Automated

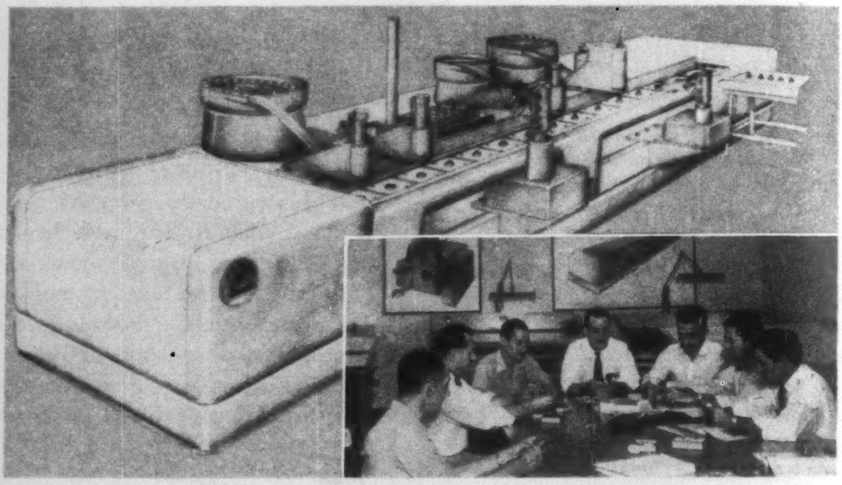
COMPLETE automation of a television station film and slide programming equipment has been demonstrated by the General Electric Co. Once the system is set into operation, supervision of the equipment is not necessary. All station breaks, commercials and programs are handled automatically. Key to the new system are inaudible tone signals recorded on magnetic tape. The introduction of the automation system was also used by GE to demonstrate new color film and slide equipment for TV stations. In the system, the color film equipment is turned on before the tape playback unit. At the appropriate time during the color sound film an inaudible tone signal causes the film to stop and a second tone activates the film center's slide mechanism, putting a stationary color picture on the TV screen. At the same time, an announcer's voice, on the same tape as the tone signals and keyed to the second tone, is broadcast. Additional tones cause other slides to appear at the proper times during the announcer's talk. At the end of the announcer's speech, a tone signal from the tape causes a new film to start running through the projector automatically.

New Basic Transfer Unit Provides For Machine Assembly

DESIGNED for automatic machine assembly of component parts and for all types of sequential machining or processing operations, a series of new straight line transfer machines has been created and developed by the firm of George H. Kendall Consulting Mechanical Engineers.

To handle the engineering of the new machine tools, a new organization, Kenhos Corp., has been formed by **G. H. Kendall Sr., Jerry A. Host** and **G. H. Kendall, Jr.** An exclusive license to manufacture and sell the complete line of Kenhos products has been granted to Karl Liberknecht Inc., manufacturers of automatic 32-station straight-line hosiery machines.

The new transfer machine is being offered with a variety of work nest sizes ranging from 6 inches to 26 inches in width and in special sizes for instrument chassis work or for other special types of work. Containing no moving parts other than a hydraulic transfer mechanism, the unit is available in standard 8 and 12-foot sections designed with an end construction that permits joining several units into a straight, L, U, or O shape production line. Individual work stations are provided with standard plug-in electrical and pneumatic circuit connections for easy attachment of necessary accessory tooling. The tooling attachments may be mounted on the top, side or underdeck for a complete freedom of placement to meet manufacturing requirements at all work stations and individual nests; automatic electrical sequencing and interlock control of attachments is provided. Simple design provides clearance from the tooling side for easy access to all tooling attachments for maintenance and changeover purposes. Kenhos Corp. offers the transfer machine complete less tooling or complete with all tooling and acceptance run tested.



ENGINEERING offices of Kenhos Corp. where application problems involving new straight-line transfer machine are worked out. Drawing shows one of new units with various tooling attachments for automatic assembly of five parts of flashlight head. Basic transfer unit can also be used in operations requiring sequence machining or for process operations, such as drying, soldering and welding.

COMBINATION of 80-per cent steel and 20-per cent plastic can be handled as easy as modeling clay—but two hours after the addition of a special hardening agent, the mixture becomes a rigid, tough, strong, steel-like mass without application of heat or pressure. Developed originally by Chemical Development Corp. for use by the metalworking industry for making tools, jigs, fixtures, and molds, it can also be used for making forming or stamping dies for metal, filling large or small holes in castings, bonding steel to itself or to other metals, etc. A holding fixture, for example which would normally take 12 hours to make of steel can now be made in 15 working minutes. A stamping die that would normally cost $250 can now be made in 30 minutes at a cost of less than $50.00.

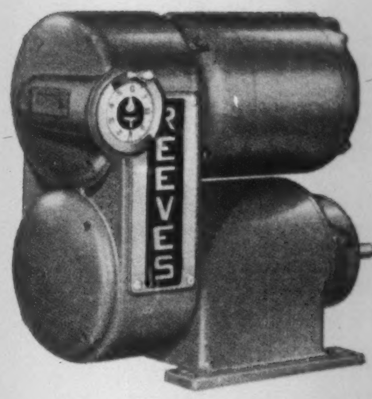
Continuous Photo Processing

REDUCED SIZE negative copies of drawings, prints or other objects are photographed automatically with equipment produced by Peerless Photo Products Inc. Work to be photographed is carried through the camera on a continuously moving conveyor. It passes through an exposure area where it is illuminated by a battery of six fluorescent tubes; a transverse slot allows a "line" of light reflected from the image to pass upward and through the optical

REEVES

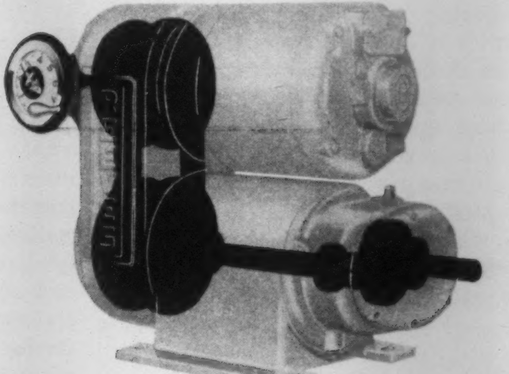
the right speed for every need!

fractional HP Vari-Speed
MOTODRIVE



compact, attractive design

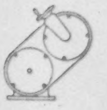
Within streamlined, metallic blue housing is REEVES' "weatherized" motor, time-tested speed changing mechanism, and heat-treated helical gear speed reducer. Maximum space for vertical model only 16 5/16" x 21½" x 11½". Other models equally compact.



simple, accurate operation

14-turn handwheel on Speedial indicator gives you stepless, accurate speeds from 3 to 4660 rpm's—within a 2:1 to 10:1 speed range. Electric remote or automatic controls also available.

45° Model



Horizontal Model

versatile application

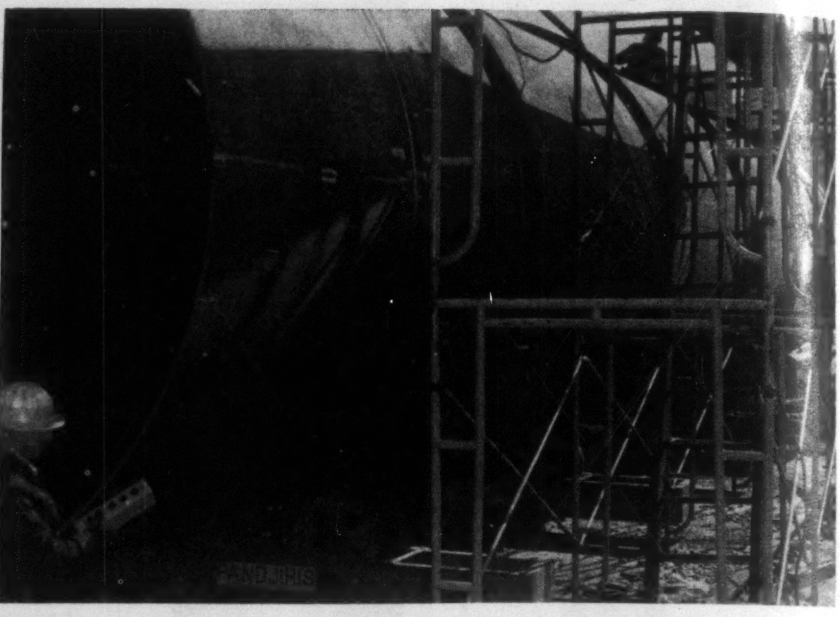
Select your *exact* needs from 112 assemblies: ¼, ½ or ¾ hp. units; horizontal left or right, vertical, or 45° left or right models; horizontal or vertical down output shaft.

Write Dept. AN19-M543 for complete bulletin.

REEVES PULLEY COMPANY • Columbus, Indiana
Division of RELIANCE Electric and Engineering Co.

system. The latter consists of a series of mirrors and a single lens which reduces the size of the image as desired. The reduced-size image then passes through another slot into the copying section where it strikes the photosensitive material.

As the drawing being copied enters the exposure area, it trips a limit switch which sets the photosensitive material in motion. It moves in perfect synchronization with the object on the conveyor. When the entire drawing has passed through the exposure area, the motion of the photosensitive material is stopped until another original is fed into the camera. The camera accommodates originals of any length and up to 42 inches wide. Photocopies can be developed easily in normal office light with the Neoflow Processer. This is a light-tight, 4-tank developing unit combined with a dryer in one package. Material is run through a series of four stainless steel tanks, containing developing, quick-stop, fixing and washing solutions. It then is directed onto the dryer. After drying, the copies can be immediately trimmed to size. If desired, they can be left as a continuous strip and wound on a spool for storage.



IN USING the turning rolls developed by Pandjiris Weldment Co., the Bethlehem Pacific Coast Steel Corp. found that the rubber tired rolls supported a 90 ton cement kiln with ease and absorbed any slight irregularities during fabrication. The quality of the inside and outside butt welds can be attributed to the smooth and precise controls of the variable speed drive of the rolls, simplifying the calibration between the electrode burn-off rate and cylinder speed of travel. Pandjiris manufactures a complete line of turning rolls, welding positioners, and special production welding equipment.

Ultrasonics Consulting Service

CONSULTING service in all phases of ultrasonics for industrial and scientific programs of any scope has been inaugurated by Vibro-Ceramics Corp., an affiliate of Gulton Industries, Inc. The new service is planned to meet the widespread needs of many industrial firms and technical researchers who wish to utilize the latest advances in ultrasonics, but who lack the specialized talents and equipment needed.

A staff of theoretical physicists and engineers headed by **Dr. Paul Oncley** has been assigned the responsibility for analyzing problems, procedures, and programs in co-operation with client needs as well as designing and constructing ultrasonic production equipment. The fields in which these consultation services are provided include: Ultrasonic processing for industry, including cleaning, emulsification, dispersion, agitation, drilling, soldering, and chemical applications of ultrasonics; ultrasonic measuring and detection devices, including flaw detection, process control, fluid or gas velocity measurements, depth indicators, and study of materials properties; ultrasonic applications in medicine and biology; and plastic deformation and fatigue in metals.

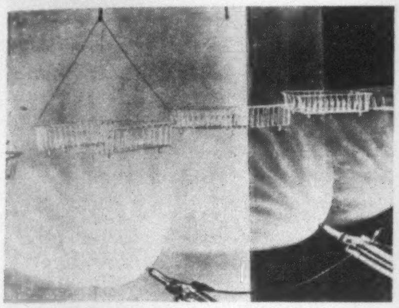
Designed for Schools

ELECTRONIC SUPERVISOR that follows preset programs and automatically switches on or off up to 40 groups of remote operations —each on its own time schedule— has been demonstrated by International Business Machines Corp. This new product will switch classroom and corridor lights on or off, sound signals denoting class schedules, recess periods, lunch, etc., control heating and air conditioning, operate flush valves, maintain accurate time throughout the building, and perform scores of similar school functions. The Central Control System is a carrier

ELGIN
MICRO-CELL

DEPENDABLE source of electrical energy for hearing aids and other small, portable, personal devices, and for military and industrial applications is provided by small battery developed by Elgin National Watch Co. The present cell, made for an electronic wrist watch now under development, is so small it occupies about the volume of a penny, yet packs enough energy to operate specialized miniature electronic devices at virtually constant 1.15 volts for two years. The cell can be made almost any size or shape desired, thus providing almost complete flexibility in the design of devices using miniature batteries.

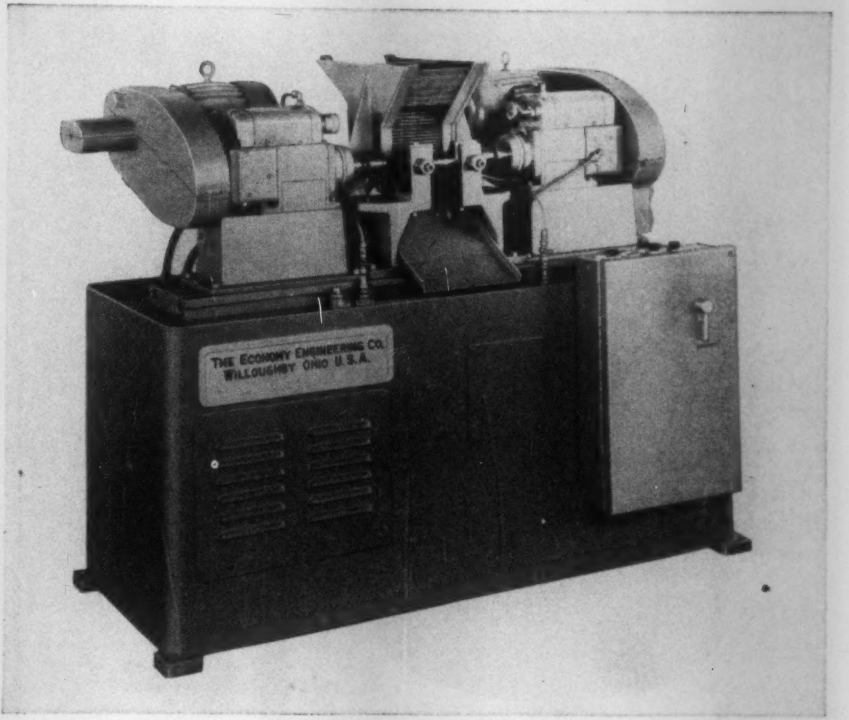
current system which requires no special wiring from its operations panel to its terminal units, utilizing commercial 60-cycle power and lighting circuits for the transmission of its supervisory signals. These command signals or pulses are superimposed on the existing circuits and in no way interfere with regular electrical functions. All operations are controlled automatically on a prescheduled basis or manually, when desired, from a central point by means of the central operations panel which is the source of the system's directions or commands.



SUCCESSFUL process for electrostatically spray-coating vinyl plastisols on fabricated wire baskets, dish drainer racks, display racks and other wire goods on a production-line basis has been announced jointly by Scientific Electric, designers and manufacturers of high frequency and high voltage equipment, and United Chromium Div. of Metal & Thermit Corp., metal finishing specialists. Electrostatic spraying of plastisol is more than twice as fast as conventional dip-coating, completely eliminates plastisol wastage due to "running", reduces the intermittent handling ordinarily required in dip-coating, and produces a superior coating in terms of uniformity and appearance to that obtained by dip methods. The entire operation is conveyorized; the actual spraying is automatic.

Small In Size Big In Performance

SILICON power diode that converts an equal amount of power as an 850-watt selenium rectifier is almost as small as one of the mounting nuts on the larger unit. Converting 5 to 15 amperes of ac to dc at temperatures as high as 371F causes very rapid aging of selenium rectifiers, even when derated. The new silicon diode developed by Raytheon Mfg. Co. performs under these conditions without aging and at efficiency levels

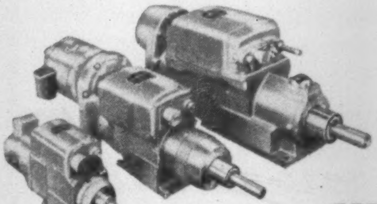


"Part per Second"
...automatically
with Hartford Drill Units*

Economy Engineering Co., Willoughby, Ohio employs two Hartford Drill Units on their standard hopper fed double end machines to taper ream 60 valve push rod tubes per minute to close tolerances.

Use of Hartford Drill Units by this well known machine builder is typical of the way in which Hartford Standardized Components can bring the benefits of low cost automation to ***every*** manufacturer. The Economy machine can produce not only automotive push rods, but can perform practically any double end machining operation on rods and tubes . . . reaming . . . facing . . . threading . . . tapping . . . centering . . . drilling . . . chamfering . . . pointing, etc. ***Any tool requirement is available with Hartford Air-Hydraulic Drill Units. Dial them all — rate of feed — distance of rapid traverse — spindle speed — final depth.*** Take a tip from the Economy story, investigate Hartford components.

*Formerly produced under the trademark "Delta-Milwaukee" by the Rockwell Mfg. Company



HARTFORD Special

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greater than 96 per cent of theoretical values. Five 26-volt selenium cells in series are required to withstand the 125-volt rms single diode rating.

The extremely high operating efficiency of the silicon diodes permits reduced power supply capacity, lower voltage drop and heat dissipation from the rectifiers. In terms of aircraft application, these features mean a saving in all important weight. In commercial applications, the silicon diodes greatly reduce package size and introduce operational savings in reduced power consumption and indefinite life. In multidiode bridge and star configurations, the silicon diode rectifier units are being applied to dc motor supplies, battery chargers, magnetic amplifier servos, and a wide variety of low and medium voltage electronic B-plus supplies. New types of applications are being encountered in increasing numbers, indicating broad new fields which can take advantage of the silicon diode properties.

Records Only During Flow

NEW start-stop mechanism that drives recorder charts only during periods of actual flow has been announced by The Foxboro Co. The device permits accurate recording of intermittent flows on gas lift and other production field operations.

In addition to a mechanical chart drive, only two components are required for start-stop operation—a bellows type actuator which is linked to a spring mechanism. The bellows, operated by a pneumatic signal (either 0 or 20 psi) from the gas flow intermitter, drives the spring which, through linkage, trips the chart drive operating lever to the start or the stop position. If an intermitter is not available, the bellows is triggered by the recording pen so that the drive starts when the pen leaves zero flow, stops when the pen returns to zero. With the chart stopped between flows, the record of each period of flow adjoins the previous, making it possible to compute gas consumption accurately.

We
gave
them
a
mountain
in
a
molehill

Ever try to remove dried cement with a steel brush? This Peerless Electric motor has a job that's just as tough. It drives a floor grinding machine that polishes stone and cement floors. Our engineers worked with the OEM's engineers to give it more than its rated horsepower, overload capacity, and the ability to overcome tremendous breakdown torque created by grinding wheels flying over rough concrete and stone. The new Peerless motor does the job to perfection.

Let's put our heads together and solve your motor problem.

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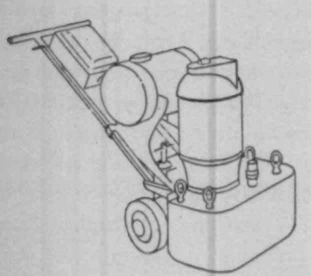
The Power
Peerless Electric
that Builds Reputations



INTEGRATED handling system at the Abner Wolf warehouse in Detroit utilizes among other tractors and trucks, the Banty produced by the Mercury Mfg. Co. Time saving innovations in the system are the radio controlled doors leading from truck dock to storage area. Unit on tractor transmits on three specific frequencies, one for each of three main doors, over distances up to 25 feet. Tractor operator does not have to stop or even await opening or closing of warehouse door when moving stock in or out of the warehouse.

Program Control Anticipated In Extrusion Press Design

SCOPE of extruded product application is being immensely broadened by the new design potentialities inherent in the several mammoth extrusion presses now being built for the Air Force as part of its heavy press program. One of these presses, a machine of 12,000-ton capacity, is currently being designed and built by the Lombard Corp. The machine is designed to use aluminum billets with a maximum diameter of 32 inches and a maximum length of 70 inches and will extrude bars or sections of any size which can be circumscribed by a circle 32 inches in diameter.

Although intended primarily for use in extruding aluminum sections, the Lombard Press will, undoubtedly, eventually be used for extrusion of many different metals, both ferrous and nonferrous. Consequently, the design of the machine embodies many features which will make it adaptable to future production requirements. One of these features is the arrangement by which various tonnages can be used. There are three basic components which establish the extrusion tonnage: (1) The main cylinder, (2) the two lateral cylinders, and (3) the piercer cylinder. By using one or a combination of these cylinders, capacity can be varied from 4500 tons to 12,000 tons.

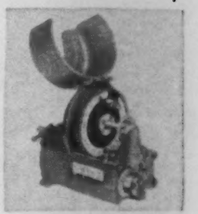
The size and speed of the press introduced a problem of control. The pressure medium is water with a percentage of soluble oil. The demand of the press required that the flow of a large volume of the hydraulic fluid be controlled and, where manually controlled, be done with only reasonable effort on the part of the operator. Lombard engineers designed a series of valves which incorporate a balancing feature that substantially reduces the amount of manual effort required for operation. To further improve press performance by including a system to permit program controlling, the valves were designed to include a motor operator drive with servo Selsyn remote control system. This innovation makes possible the introduction of any number of required electrical interlocks and a system of automatic or semiautomatic program controlling. Some idea of the size of the valves can be

CIRCUIT CONTROLLING COUNTERS *with* *Automatic Reset*

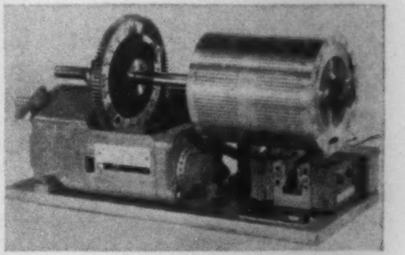
FOR REVOLUTION, STROKE AND ELECTRIC COUNTING

THESE predetermining counters with instantaneous reset will automatically recycle a variety of single and multi-stage switch functions. Recycling operates without time lag at speeds to 5,000 rpm. The switching pattern repeats automatically as long as desired. The control circuit is an integral part of the equipment.

CYCLO-MONITORS



Used to control one or two switching events within a preset count-cycle. Replace unwieldy change gears, cam systems, timing chains, etc.—provide quick and completely flexible adjustment for changing requirements. Adjustment in one-count increments extends over a wide range of numbers. Available in a variety of models—*write for General Catalog of Cyclo-Monitors.*



PROGRAMONITORS

Same cycle range as Cyclo-Monitors, but also permit ANY NUMBER of intermediate switching events. Complex switching patterns of any countable sequence can be programmed and automatically repeated. Momentary or dwell switching—continuous or intermittent operation. Built-in control circuit can be opened or closed at any numbers. *Write for Bulletin 505.*

COUNTER AND CONTROL CORPORATION

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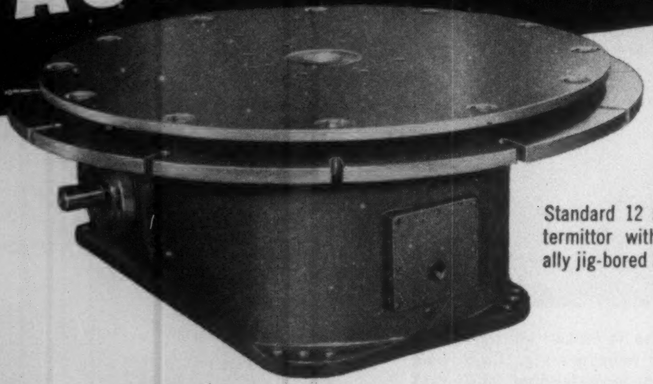
STANDARDIZED AUTOMATION!



Standard 12 stop Intermittor with specially jig-bored 36" dial.

HIGH SPEED INDEX TABLES FOR LARGE VOLUME PRODUCTION

Up to 30,000 Pieces per Hour with

The FERGUSON INTERMITTOR!

Standard 6 stop Intermittor with 12" dial and optional tool mounting brackets.

OVER 150 STANDARD MODELS TO CHOOSE FROM:

NO. OF STATIONS
4, 6, 8, 12, 16, 24, 36
DIAL SIZE
12", 18", 24", 30", 36", 48
INDEXING TIME
¼, ⅓, ½, ¾ of cycle

COMPLETE CATALOG

Every engineer should have a copy of Catalog No. 300 which gives load ratings and all dimensions of more than 150 standard Intermittors. Send for your file copy today . . . no obligation.

The new standard Ferguson Intermittor is a *must* for operations such as machining, joining, forming, staking, piercing, assembling, testing and inspection that require a combination of high speeds, long dwell or work time, and smooth indexing.

There is a standard Intermittor for almost every application, offering a choice of stops, dial size, degree of movement; and a table for either extreme precision or high torque usage. Seldom do you have so much selection in a line of standard production machinery . . . with all of the benefits of standardization PLUS many of the advantages of custom designs! The Intermittor operates at speeds far greater than those possible with other types of index tables. The special acceleration characteristics of the FERGUSON ROLLER GEAR DRIVE insure smooth starting and stopping with little shock and vibration, at speeds up to 500 indexes per minute.

Save design time, simplify tooling, improve product quality and cut maintenance costs to rock bottom with the new Ferguson Intermittor . . . the "Packaged" precision index table for high speed production.

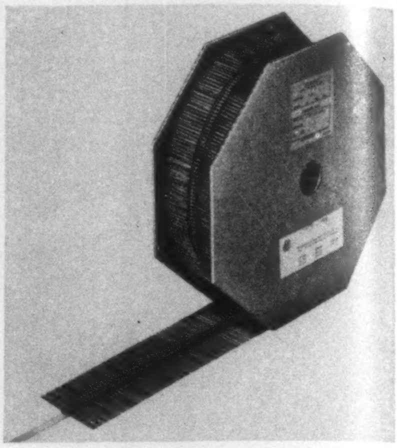
WRITE FOR CATALOG NO. 300

ferguson

FERGUSON MACHINE & TOOL CO., INC.

ROLLER GEAR DIVISION, DEPT. AI-10 P. O. BOX 5841, ST. LOUIS 21, MO.

gained from the fact that at one point in the system, the engineers were forced to valve a flow of 9600 gpm at 4500 psi.



SPECIAL method of packaging ½-watt, 1 watt, and 2 watt fixed resistors is offered by the Allen-Bradley Co. for chassis automatic assembly lines. The resistors are attached to the adhesive surface of a pressure sensitive tape, which adheres only to the body of the resistor—not to the leads. The reel, which is expendable, consists of a pair of octagonal, corrugated board ends with metal bearings for use with 9/16-inch mandrels.

NEW division to be known as the Giannini Datex Division has been formed by G. M. Giannini & Co., Inc. The division will manufacture digital data handling systems and will be expanded to include equipment for automatic control and data recording for industrial processes. **Carl P. Spaulding** has been elected Vice President of the parent company and has been named General Manager of the new Datex Division. Prior to joining the company three years ago, Spaulding was a staff member of M.I.T.'s Radiation Laboratory and Project Engineer with Consolidated Engineering Corp.

Intraplant Dial-Phone

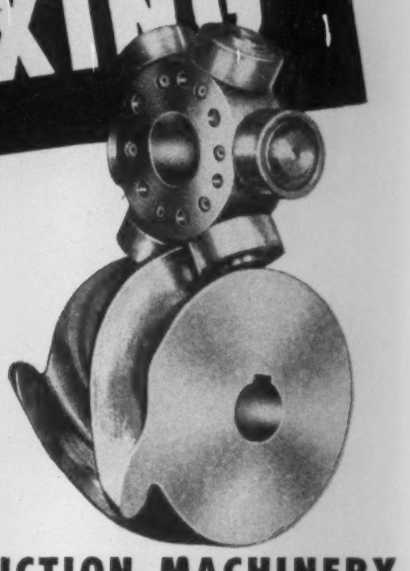
AUTOMATIC dial-phone system for rapid, economical intercommunication in business offices, industrial plants, and institutions was announced by **J. F. O'Brien**, manager, theatre and industrial equipment marketing, engineering products division, Radio Corp. of America. Known as "Auto-Dial," the system is built around an automatic, unattended central switchboard through which each telephone in the intercommunication network can be dialed directly. To meet a range of budget and network rquirements, the switchboard is available in various capacities—for 10 lines, 25 lines, 50 up to 1000 lines. The intercom system's telephones or handsets compare in size and appearance with conventional telephone equipment and feature governor-type numeral dials which can be speed adjusted.

MANAGER of recently established New Products Div. of Clark Controller Co. is **Ben H. Carlisle.** The new division includes two departments: A development department, responsible for initiating and developing new products, and a product adaptation department, responsible for readying development department projects for production and sale. Carlisle, a graduate of Duke University was formerly in the applied engineering department of the Clark Controller Co. before assuming his new responsibilities.

Industrial Park Development

PLANS for the development of an unique $10 million industrial park site, particularly suited to the needs of the instrumentation industry, have been announced by **E. L. Baker,** the developer, and the Industrial Department of the Fort Worth, Texas, Chamber of Commerce.

The park will offer to industry a combination of out-of-city comforts and attractiveness and in-city conveniences for employees and industrial operations. It will be built with the premise that an industrial



HIGH SPEED INDEXING

WHEN TO SPECIFY A FERGUSON DRIVE

IN YOUR NEW PRODUCTION MACHINERY

WHEN INDEXING SPEEDS LIMIT YOUR PRODUCTION . . .

OR IF YOU REQUIRE SMOOTH STARTING AND STOPPING . . .

OR YOU NEED PRECISION OF .001" WITHOUT AUXILIARY LOCKING DEVICES . . .

OR IF MAINTENANCE "DOWN TIME" IS A MAJOR PROBLEM . . .

There's No Place in Automation for Obsolete Indexing Devices

Modern production methods require speeds and precision impossible to obtain with geneva drives and other obsolete indexing devices. The Ferguson Roller Gear Drive makes it possible to increase production speeds as much as 100%, *while improving product quality and reducing maintenance costs!* The Ferguson Drive, the greatest development in indexing in the last thirty years, attains indexing speeds up to 1,000 per minute in some applications without undue shock or vibration to the Drive or machine. If you have machinery utilizing dial feeds, roll feeds, carrier chains and other types of intermittent feeding methods, investigate the Ferguson Drive and discover what it can do for you.

NOW IN STOCK!

CUT WEEKS OFF DELIVERY TIME!

The more widely used Ferguson Drives may now be ordered from stock with weeks cut off delivery time and prices reduced as much as 25%. Send in the attached coupon or write for Bulletin 105a to get full information, including load ratings, dimensions and data on selecting a Drive. Find out how inexpensive it is to modernize your production machinery, increase production and lower operating costs.

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FERGUSON MACHINE & TOOL CO., INC.
Roller Gear Division Dept. A-10
P. O. Box 5841 St. Louis 21, Mo.

Send free copy of bulletin 105a and data on stock and standard Ferguson Drives for high speed precision indexing of production machinery.

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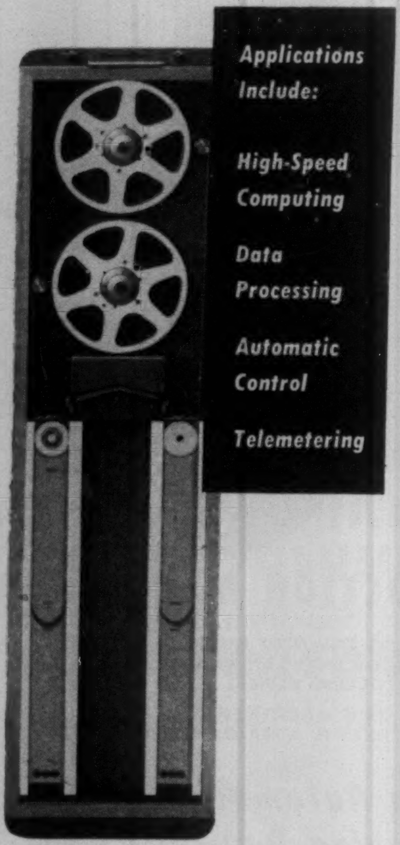
COMPANY__________

STREET__________

CITY__________ STATE______


DataReader
Model 546

A transport unit for high speed searching, reading and recording of data on magnetic tape.

Applications Include:
High-Speed Computing
Data Processing
Automatic Control
Telemetering

PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.
HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.
TWO-DIRECTION SEARCH—either direction, automatically at full speed.
REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.
VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.
END-OF-TAPE SENSING—stops automatically at either end of tape.
RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

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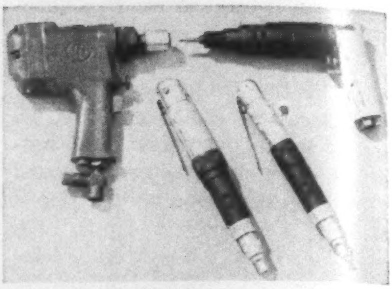
ElectroData Corporation maintains a nationwide sales and service organization.

area can be attractive and an asset to the appearance of a community. The area will be developed on a lease basis, in line with present industry preferences, so that no capital investment will be required by the industrial users. The sites and the buildings to be erected upon them will be available under long-term leases with options to buy. The developers will build on each site to specifications of the lessee. Service railway tracks will be available to serve each industry individually and the lead and service tracks will be so located that each site will be served from the rear, keeping the front open to maintain the parklike appearance.


SERIES of new torque-controlled, portable power screwdrivers and nutrunners for efficient, high-production-rate applications has been developed by the Chicago Pneumatic Tool Co. The tools feature a new type of magnetic clutch which gives precise control of fastener tightness and a new type of acoustic baffle which lowers operating noise. Thirteen models, including both reversible and nonreversible types, handle the range of sizes most commonly encountered on production lines.

MEETINGS AND EVENTS

Oct. 20-22—
Institute of Management Sciences. Annual national meeting will cover use of data handling and computing equipment as tools of management. To be held Park Sheraton Hotel, New York. Additional information may be obtained from A. N. Seares, Remington Rand, 315 Fourth Ave., New York 10, N. Y.

Oct. 23-29—
Instrument Society of America. Symposium of Philadelphia Section devoted to electronic and pneumatic automatic control loops. To be held Penn Sherwood Hotel, Philadelphia. Additional information may be obtained from R. F. Eisele, 4907 Stenton Ave., Philadelphia 44, Pa.

Oct. 24-26—
American Standards Association. Sponsored by ASA and National Bureau of Standards. Thirty-seventh annual meeting to be held in conjunction with Sixth National Conference on Standards to be held Sheraton-Park Hotel, Washington, D. C. Additional information may be obtained from society headquarters, 70 East 45th St., New York 17, N. Y.

Oct. 27-28—
National Conference on Industrial Hydraulics. Sponsored by Illinois Institute of Technology, and Armour Research Foundation. To be held LaSalle Hotel, Chicago. Additional information may be obtained from C. A. Arents, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Nov. 7-9—
Eastern Joint Computer Conference and Exhibition. Sponsored by American Institute of Electrical Engineers, Institute of Radio Engineers, and Association for Computing Machinery. To be held Hotel Statler, Boston. Additional information may be obtained from Arrangements Committee, Box 223, Boston 1, Mass.

Nov. 13-18—
American Society of Mechanical Engineers. Diamond Jubilee Annual Meeting to be held Congress, Conrad Hilton and Sheraton-Blackstone Hotels, Chicago, Ill. Additional information may be obtained from T. A. Marshall Jr., 29 West 39th St., New York 18, N. Y.

Nov. 14-18—
American Society of Mechanical Engineers. Exposition of power and mechanical engineering in conjunction with 75th anniversary meeting. To be held Chicago Coliseum, Chicago. Additional information may be obtained from In-

ternational Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Nov. 28-Dec. 1—
Air Conditioning & Refrigeration Institute. Ninth Air Conditioning & Refrigeration exposition to be held concurrently with national conventions of five interested societies and associations including the American Society of Refrigerating Engineers. Show to be held in Auditorium, Atlantic City, N. J. Additional information may be obtained from Institute headquarters 1346 Connecticut Ave., N.W., Washington, D. C.

Dec. 5-9—
Twenty-fifth Exposition of Chemical Industries. To be held Commercial Museum and Convention Hall, Philadelphia. Additional information may be obtained from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Dec. 10-16—
International Atomic Exposition. To be held Public Auditorium, Cleveland, Ohio. Additional information may be obtained from International Atomic Exposition, 931 Book Bldg., Detroit 26, Mich.

Dec. 12-16—
Engineers Joint Council. Coordinating activities of 29 business and technical societies in co-sponsoring of Nuclear Engineering and Science Congress. To be held Public Auditorium, Cleveland, Ohio. Additional information may be obtained from Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

ENGINEER
AUTOMATION

"Him and his automation!"

INDUSTRY rolls...

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Across industry . . . in plants of all types . . . BUSCHMAN conveyors are setting new records for materials handling economy and efficiency. Engineered to individual production needs, these conveyor systems streamline plant operations . . . eliminate bottlenecks . . . reduce manual handling to absolute minimum.

BUSCHMAN offers a wide range of types and sizes to cover widely diversified materials handling applications. Gravity roller and wheel . . . live roller . . . powered belt . . . apron . . . overhead cable . . . or special conveyors can be supplied. In addition, BUSCHMAN engineers are prepared to survey your plant and to recommend the most practical, economical and efficient type of conveyor for each installation.

Whatever your materials handling requirements . . . specify BUSCHMAN for durable, versatile, profitable conveyor systems.

BUSCHMAN-designed switch and spur sections provide maximum versatility.

Typical combination system utilizing live rollers and gravity wheels.

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DETROIT DATELINE

By **FLOYD G. LAWRENCE** Detroit Editor

NOW LARGE-SCALE ASSEMBLY

QUALIMATIC is the word used at Plymouth Div. of Chrysler Corp. to describe quality control through automatic processes as applied at their new V8 engine plant in northeast Detroit. The techniques of automation applied there will be marked by many as highly significant.

Perhaps most impressive feature is the final assembly line. In other engine assembly plants, the final line is a slow-speed conveyor which moves continuously past assembly stations. At Plymouth's new plant the final line is actually a transfer line which indexes from one station to the next. Engines are positioned at each station within 0.005-inch, making possible the use of nut feeding and running equipment. Engineers estimate that about 30 per cent of the final assembly is currently being done automatically by such equipment, and estimate that more than 50 per cent can ultimately be done in this way.

This type of final assembly line is a move in the auto industry to watch. Engineers, plagued with poor quality and high labor costs in final assembly of cars as well as their components, figure that the next major field of automation application will be in the assembly area. This indexing transfer line built by Cross Co. to replace the assembly conveyor will undoubtedly be a precedent-setting device in the industry.

Also among the items of specific equipment that are notable are the engine hot-test stands. Each of these 72 stands carries the hot-test operation to new highs of automaticity. Engines move from the final assembly area to the stands on a waist-high conveyor. Probes on the engine carrier locate an empty test stand and the engine is diverted into the stand automatically. Impact of the engine trips a limit switch starting a sequence timer. First the engine is clamped.

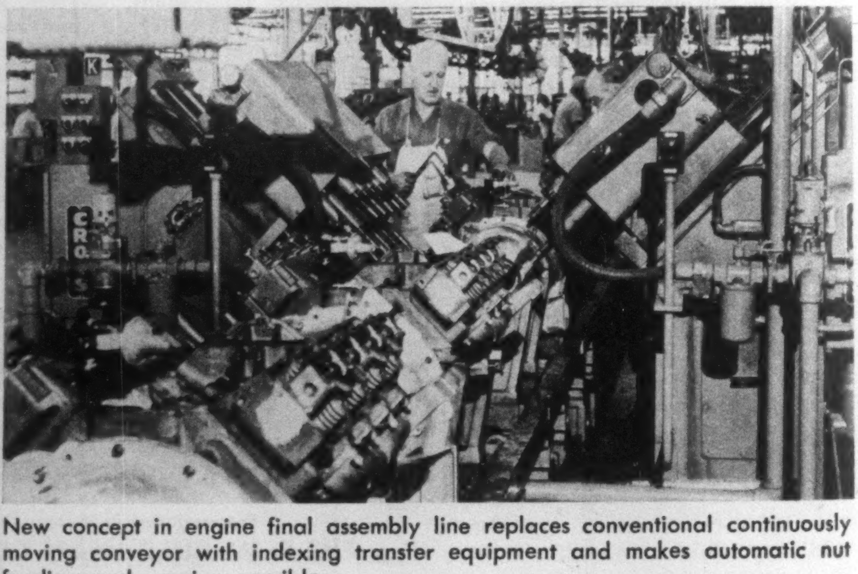
Then a natural gas carburetor is clamped against the intake manifold orifice. Exhaust ducts, water and oil lines are similarly clamped.

When the engine is ready, the timer trips a starter mechanism which cranks the engine and releases when the engine starts. Should the engine fail to start, a light goes on signaling this fact. Having started, an engine is run through a 20-minute performance cycle and then signals an attendant that the test is completed and the engine is ready for its final visual check for gasket leaks, etc. Up to this point, the entire cycle is performed without any human attendance.

Another feature claimed to be unique in the industry is the use of Detecto panels developed by W. F. & John Barnes Co. which pinpoint the exact location of any machining troubles along the line.

Perhaps the Plymouth engine plant is best summed up as "integrated automation." They have used small, fast machines that can be tied together into flexible automation units. While they may not look as ingenious as the larger machines, neither are they as complex. The result, Chrysler spokesmen maintain, is more spectacular production and reliability.

Chrysler spokesmen, noting that we must increase our production 40 per cent in the next ten years if we are to improve our standard of living at the rate of the last 25 years, cite automation as a major key in that achievement. The Plymouth engine plant may well prove to hold several keys useful in future automation.



New concept in engine final assembly line replaces conventional continuously moving conveyor with indexing transfer equipment and makes automatic nut feeding and running possible

Few Limitations

"Besides," he pointed out, "automation is not practical or, in most cases, even available to small manufacturers because of the tremendous capital investment required."

Statements to this effect have been made time and again by industrialists for varying reasons. The interesting fact is that small manufacturers themselves have thoroughly disproved this erroneous assumption. Automation in widely varying levels has been developed with great success by small manufacturers. In a recent statement L. L. Colbert, president of Chrysler Corp., pointed out this fact.

"At a time when we are hearing more and more about the automatic factory and automatic methods of producing, or automation as some call it, it might seem that this trend too would make it difficult for relatively small manufacturers either to enter or to stay in the automobile business. This is not necessarily true. Automation can be used on a small scale as well as on a big scale. Many of our small suppliers use automation. Automatic machinery for producing engines is in general use throughout the industry, regardless of the size of the company."

Another authority emphasizes the broad front for practical application.

"There is already an opportunity for the benefits of automation to be extended into most all kinds of business—large, small and medium-sized. The extent to which it can be applied economically is determined not by the size of the business but rather by the volume and nature of the individual end-products or particular components manufactured. And the price tags on automatic machines go from above one million dollars to as low as fifteen hundred dollars."

With an understanding of the overall principles involved, successful automation on a suitable scale for any business can be established. With a positive approach, a progressive attitude, open mindedness and determination, effective results beyond all expectations will be the reward.

Bolz

EDITOR

Success smiles on those who draw on the experience of all industry in automatic operations. Through this technology of automation, an answer can be found to stiffening competition—flexibility combined with reduced costs

MODERN PRODUCT—AEROSOLS
MODERN PRODUCTION—AUTOMATION

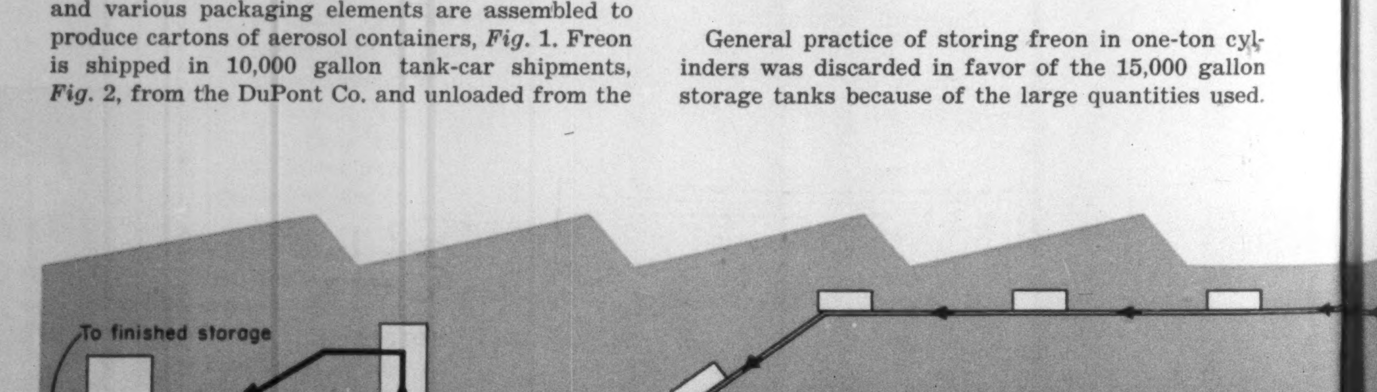
By **DON W. HARRY**
Assistant Plant Engineer
Stanley Home Products Inc.
Easthampton, Mass.

PACKAGING, at times, is difficult to separate from an extended assembly operation—packaging may be considered as assembly of product and package. This is particularly true when packaging materials are fed into the line at various stations and assume the same status as product components. Automation encompasses this hybrid assembly-packaging.

Manufacture of aerosol products at Stanley Home Products is such an operation. Concentrate, freon and various packaging elements are assembled to produce cartons of aerosol containers, *Fig.* 1. Freon is shipped in 10,000 gallon tank-car shipments, *Fig.* 2, from the DuPont Co. and unloaded from the tank car into two 15,000 gallon freon storage tanks. Weight of these tanks is recorded through Baldwin-Lima-Hamilton strain gages, *Fig.* 3. These devices keep a record of the freon inventory and usage, and are valuable aids in detecting any leaks which might occur in the storage system—freon is expensive.

Handling Liquids

General practice of storing freon in one-ton cylinders was discarded in favor of the 15,000 gallon storage tanks because of the large quantities used.



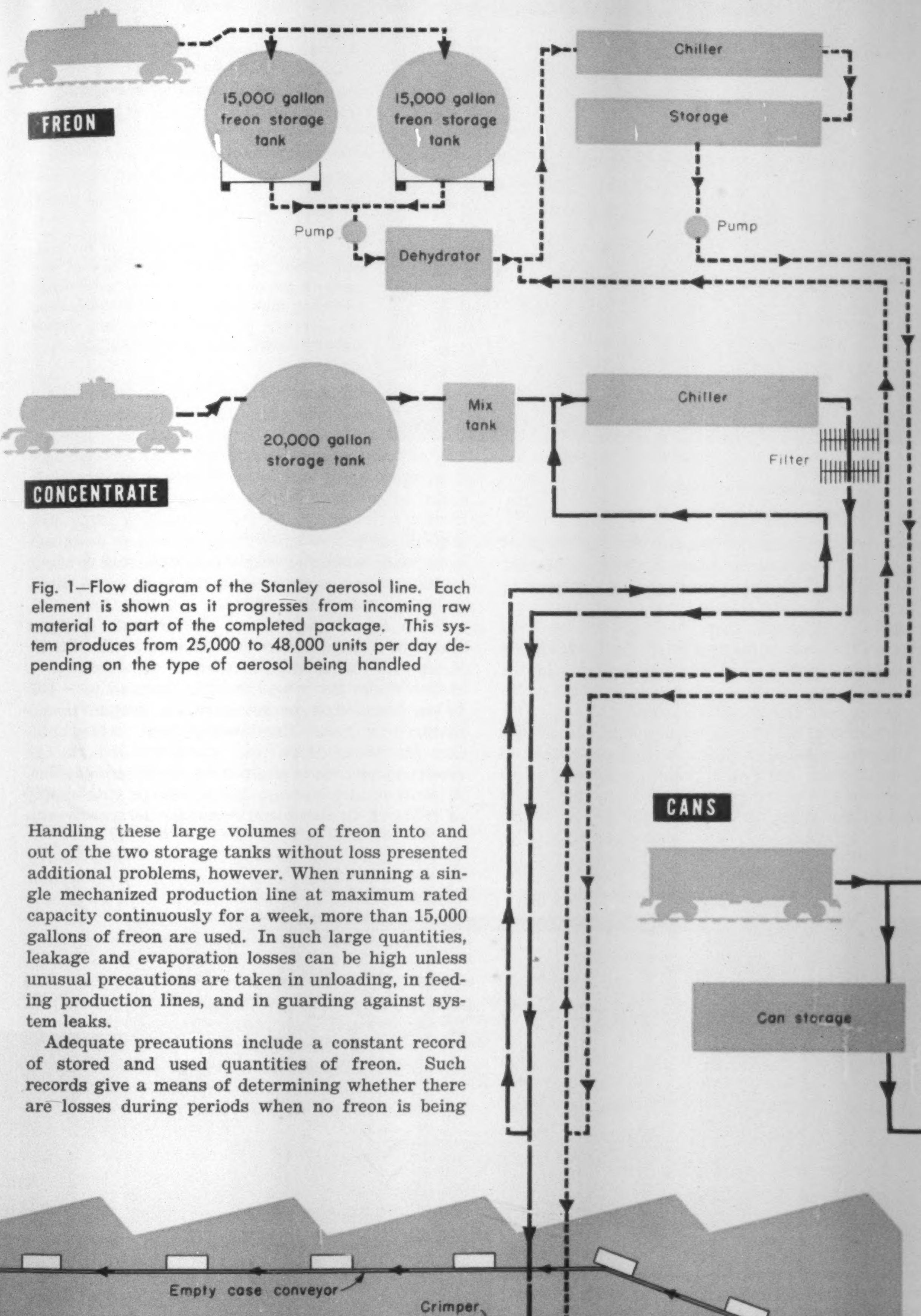

FREON
15,000 gallon freon storage tank
15,000 gallon freon storage tank
Pump
Dehydrator
Chiller
Storage
Pump
CONCENTRATE
20,000 gallon storage tank
Mix tank
Chiller
Filter
CANS
Can storage
Empty case conveyor
Crimper
Valve test
Hot water bath
Check weigh
Filler
Can cleaner
Coder
Uncaser

Fig. 1—Flow diagram of the Stanley aerosol line. Each element is shown as it progresses from incoming raw material to part of the completed package. This system produces from 25,000 to 48,000 units per day depending on the type of aerosol being handled

Handling these large volumes of freon into and out of the two storage tanks without loss presented additional problems, however. When running a single mechanized production line at maximum rated capacity continuously for a week, more than 15,000 gallons of freon are used. In such large quantities, leakage and evaporation losses can be high unless unusual precautions are taken in unloading, in feeding production lines, and in guarding against system leaks.

Adequate precautions include a constant record of stored and used quantities of freon. Such records give a means of determining whether there are losses during periods when no freon is being

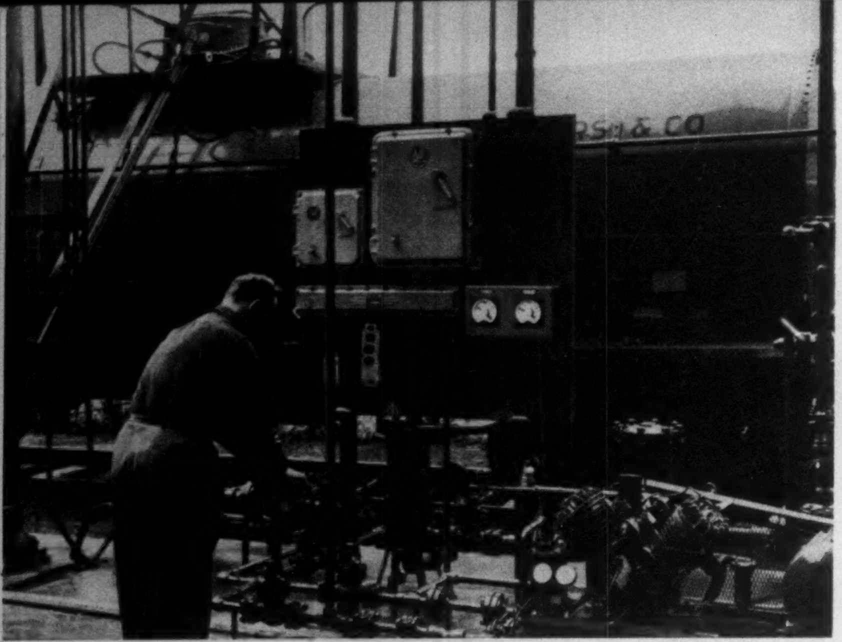


Fig. 2—Two weight indicators on the control panel for motor-driven pump and compressor at trackside are used when emptying tank cars. These indicators show the quantity of freon in the two distant storage tanks

withdrawn and a means of checking the extent of evaporation losses in the filling operation. Weight is the only satisfactory measure of stored quantities because it is not affected by pressure and temperature. Although glass sight-gages are provided on the ends of the two cylindrical tanks, they give only a rough check because volumes in the liquid and vapor phases vary widely with the quantity in the tank and its temperature.

Instrumentation provides for weight indications at three points—beside the can filling position on the production line, at a point between the two tanks, and at the tank car siding. A motor-driven pump at the siding is under control of the weighing system to the extent that it is shut down automatically when the weight corresponding to about 13,500 gallons of freon is in the tank. The tanks are never completely filled.

From the storage tanks, the freon is pumped through a dehydrator furnished by the C. M. Kemp Co. After dehydration, it goes through a chiller where its temperature is dropped to −30F by an ammonia-type refrigeration system manufactured by Arctic Engineering Corp. After chilling, the freon drops into a refrigerated storage receiver and then is pumped to the filling machine. A recirculating line assures a refrigerated supply of freon at all times and evens temperature varia-

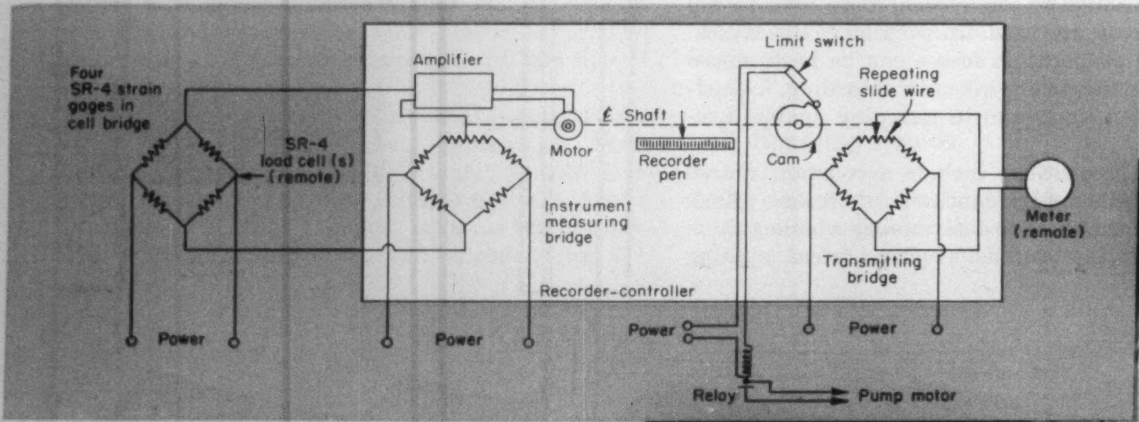
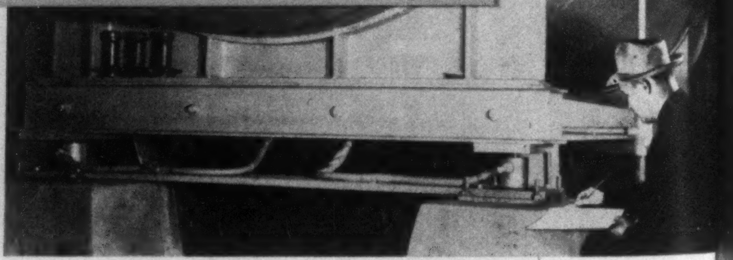

Four SR-4 strain gages in cell bridge
SR-4 load cell (s) (remote)
Power
Amplifier
Motor
℄ Shaft
Recorder pen
Instrument measuring bridge
Power
Recorder-controller
Limit switch
Cam
Repeating slide wire
Transmitting bridge
Meter (remote)
Power
Power
Relay
Pump motor

Fig. 3—Instrumentation for gaging 15,000-gallon freon tanks and controlling the pump which delivers freon from tank cars to storage tanks. Actually there are two SR-4 load cells in series to weigh each tank and two remote weight-indicating meters, one near the storage tanks and one on the instrument panel at trackside. The circuit is duplicated for the two storage tanks



tions. The filling machine pours freon into the empty aerosol cans in four stages.

Deodorized kerosene is received in tank car shipments and is stored in 20,000-gallon underground storage tanks. When making up a batch, it is pumped into a mixing tank where various additives are introduced to form the final mix, less freon. From the mixing tank, the solution is pumped into a chiller where the temperature is dropped to 4F. It is then filtered and pumped to the filling machine where it is sealed in the second stage of this machine.

▶ Unpackaging and Packaging

Cans are received directly from the supplier in shipping cases. From the box car, cases are either conveyed directly onto the line or are palletized and sent to a storage area, depending on the particular product being run. From the storage area, they are moved by Lamson conveyor to the infeed end of the production line, *Fig.* 4. Here an uncaser designed and built by A-B-C Packaging Machine Corp. automatically removes cans from cases, *Fig.* 5. Flow of cases to this machine is controlled by two limit switches at both exit and entrance to prevent jamming.

After the cans are removed, *Fig.* 6, cases are shunted on an overhead conveyor which runs to the case packer at the end of the production line. Cans continue on to a coding machine manufactured by American Marking Corp. which records the day, month, year and batch number on each can. They then proceed through a Pneumatic Scale Corp. cleaner which removes any carton lint and dust which might plug the valve when the can is put to use. After cleaning, the cans are run under a spout, first filling freon and then the concentrate, *Fig.* 7. On the same machine, valves are placed on the can and crimped in position, *Fig.* 8. An Exact Weight Scale Selectrol takes the cans from the filler and check-weighs each can for accuracy of filling, *Fig.* 9.

After this, cans enter a hot water bath where an inspector checks them for leakage or distortion. To prevent the newly filled cans from tipping in the hot water bath, a magnetized conveyor built by Great Lakes Runway and Engineering Co. is used. Immediately following the hot water tank, each can passes a valve testing station and then enters a Consolidated Packaging Machinery Corp. capping machine which automatically places the protecting cap on the container. They then proceed to the packing table and enter an Emhart Mfg. Co. case packer which automatically groups the cans by 12 or 24, depending on the product being run, and assembles the cans with their respective partitioned cases. Filled cartons enter a case sealer which closes and seals the flaps.

From there, cases go into a RoboLift case elevator, *Fig.* 10, which raises the cases vertically 12 feet to clear an access aisle. They are conveyed onto a plant-wide conveyor system which carries them to the end of the building housing the aerosol

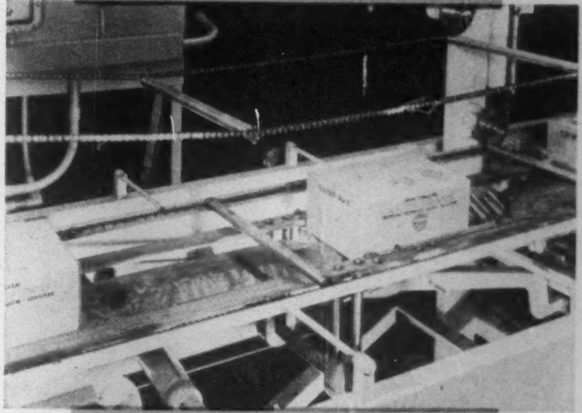


Fig. 4—Case containing empty cans being opened. The case on the left moving out of the picture has underside flaps already opened

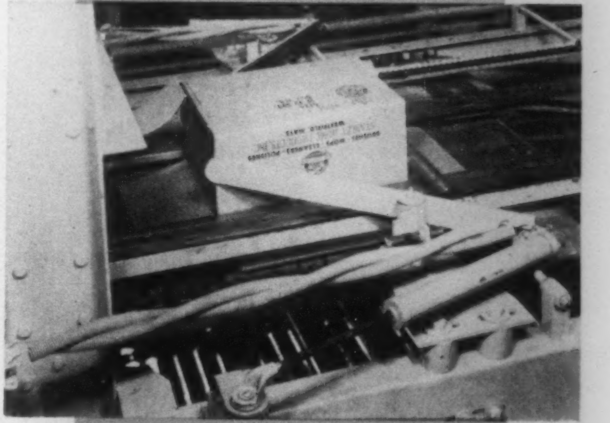


Fig. 5—Infeed of case unpacker where the case is separated from empty cans. Limit switches control the flow of cases to this machine to prevent jamming

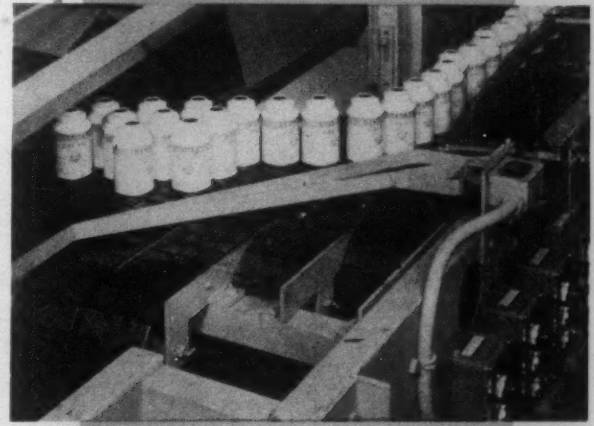


Fig. 6—Discharge side of case unloader showing empty cases moving off above and empty cans being fed onto the line. Note the limit switch on the right actuated by an excess of cans

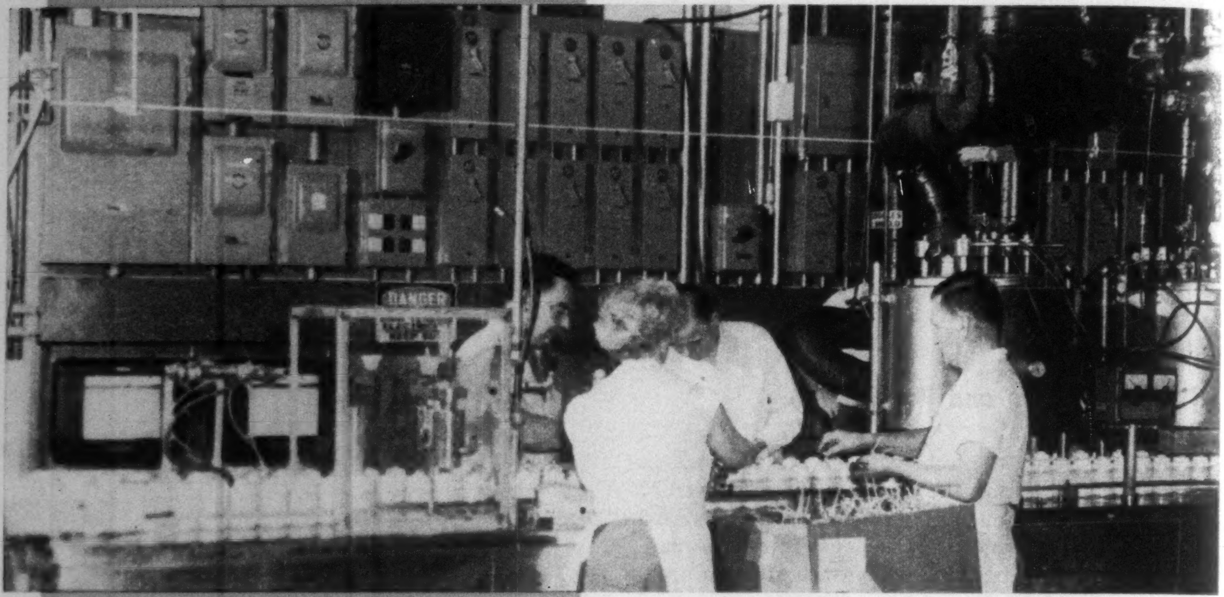


Fig. 7—Filling machine on right pours both freon and concentrate into cans. Next operation on this machine, manufactured by Alpha Engineering Machine Works, involves inserting of valves

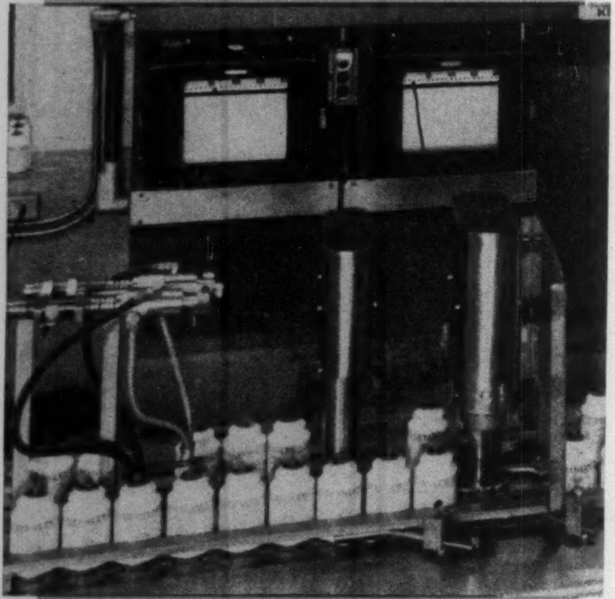


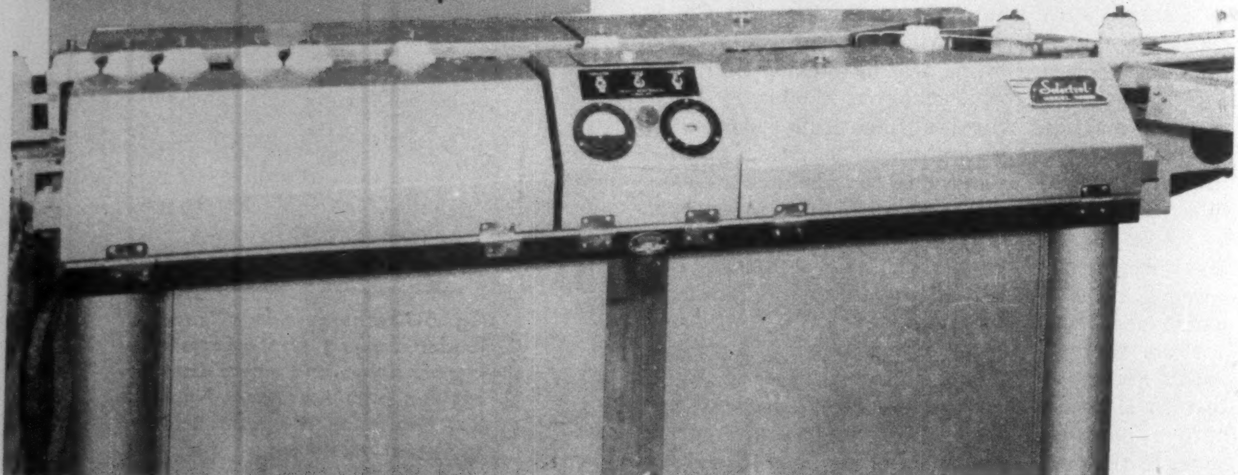
Fig. 8—Valve crimping station with cover removed. Charts in the background indicate stored freon and rate of consumption

line. Cases are palletized through the use of a semiautomatic palletizer of Stanley design, shown in *Fig.* 11.

▶ Speed and Flexibility

Designed to be supplied with cans either directly from a freight car or from a storage area, the system can use either 6-ounce or 12-ounce aerosol cans manufactured by American Can Co., Continental Can Co., or Crown Can Co. The line is

Fig. 9—Selectrol weighing unit which separates off-weight cans from those correctly filled



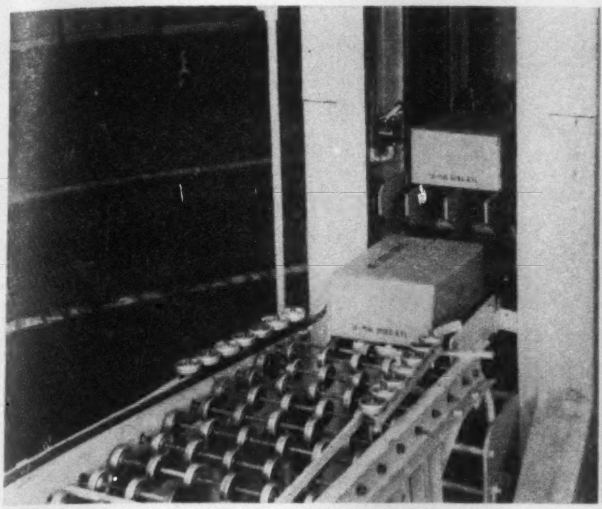


Fig. 10—Packed cases pass over an aisle after being raised in this elevator. Cases are palletized on the other side of the aisle

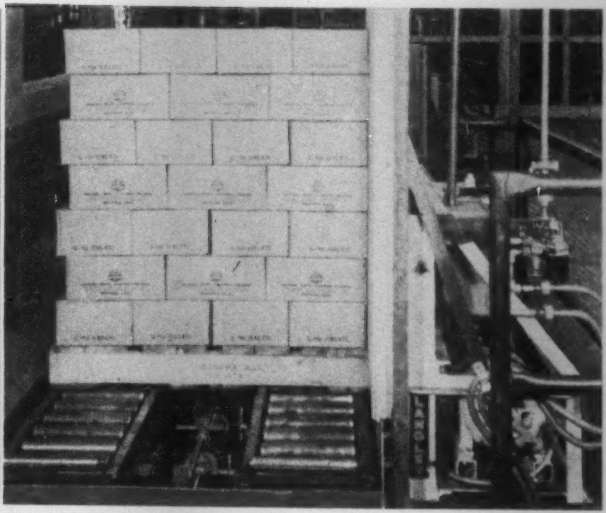


Fig. 11—Fully loaded pallet being ejected from the pallet loading platform. Fork lift trucks carry loaded pallets to storage area or freight cars

also capable of handling both space-type aerosols such as insecticides, room deodorants, mothproofers, etc., and foam-type aerosols such as shaving cream, hand lotion, or shampoo. The line is automated from the can uncaser through to the palletizer, requiring 12 operators including the mixer. Depending on the type of aerosol, production runs from 25,000 to 48,000 units per day.

Previous to the time that Stanley Home Products went into the aerosol business, most aerosol packaging was handled by contract packagers. These lines were not constructed for high speeds or operating efficiency. It was Stanley's view that in order to compete successfully with these highly flexible lines, Stanley must produce at high speed by automatic means without sacrificing flexibility. In order to accomplish this, the feasibility of applying standard techniques of automation used in the chemical industry was investigated. It was also found that machinery and equipment could be bought readily as standard equipment and fitted into this particular line. Hence, most of the machines in this line were bought on the open market and have been converted to use with aerosols.

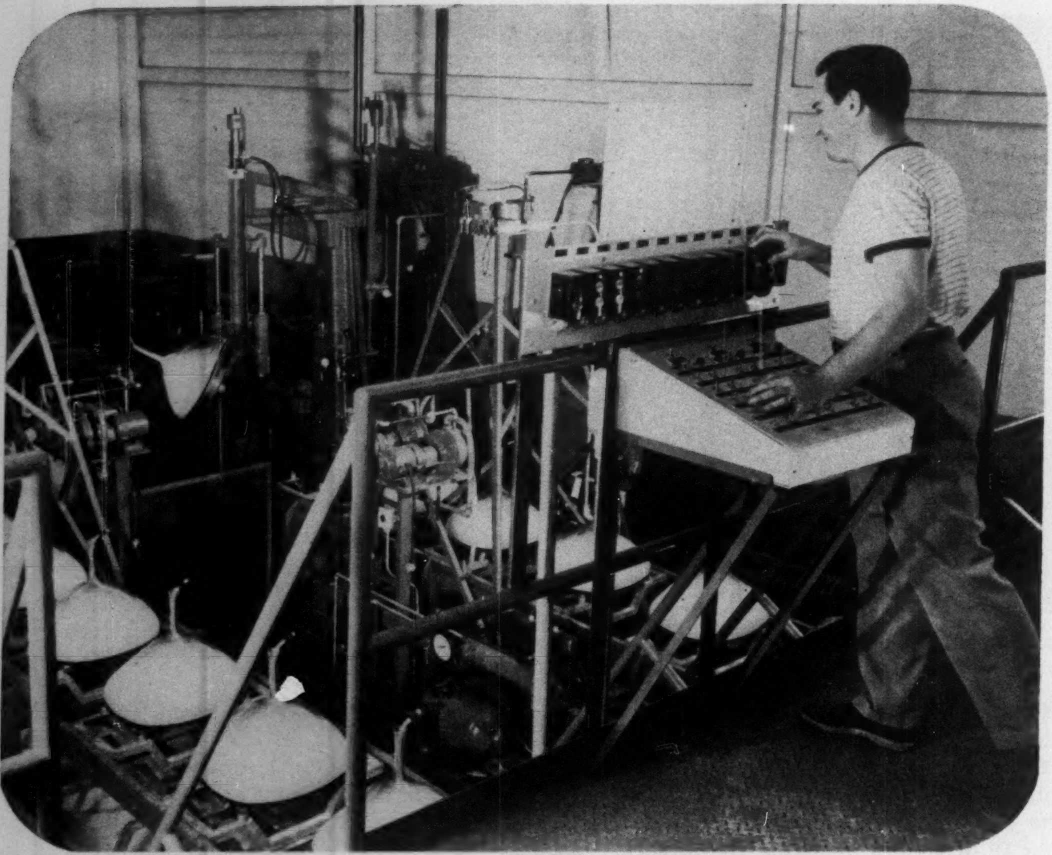
AMA STUDY IDENTIFIES TYPICAL FOREMAN

ACCORDING to a survey of foremen's compensation just released by the Executive Compensation Service of the American Management Association, the "typical" American production foreman earns $6241 a year. The survey, conducted from December 1954 to February 1955 covered 6500 foremen in more than 100 companies in various sections of the country. From its results emerged the following profile of the "typical" production foreman:

He is 45 years old and has been on his present job 8½ years. He supervises 42 hourly workers. Last year his salary was raised by 6.3 per cent; he might have been one of the 66 per cent who received raises in 1954. He may or may not have received a bonus in addition to his regular salary; bonuses were paid last year to 40 per cent of the durable-goods-industry foremen included in the survey. The study covered four categories of foremen: The "typical" production foreman, the foreman of a major production department, the general foreman, and the maintenance foreman.

In durable-goods industries the average major-department foreman earns $7416 a year; the average general foreman, $8479 a year; and the average maintenance foreman, $6822. All these figures apply only to first-line supervisors in durable-goods industries.

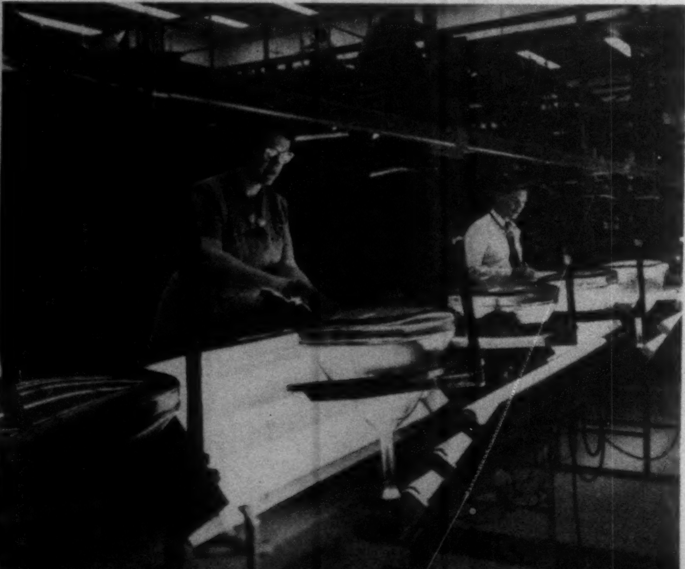
In non-durable-goods industries salaries, salary increases, and bonuses of foremen tend to be somewhat lower. The average major-department production foreman earns $6586 a year in non-durable-goods industries, and the average general foreman in these industries earns $8000. The only exception to this rule is the maintenance foreman, apparently because the skills required are much the same regardless of the industry. For him the salary difference is much less; in non-durable goods he earns $6716 a year, compared to $6822 in durable goods. Only 25 per cent of the individuals in the "typical" production foreman category in non-durable-goods industries received bonuses last year. Raises were given to 54 per cent of them, and the average salary increase was 6 per cent during the period surveyed.



1 This is Sylvania Electric Products Inc. television picture tube screen settling room. One man can control movement of bulbs as they progress through room to next operation. Here, after a precise period of screen settling, automatic suction arms lift the bulbs from their carriers on the conveyor line and spill the chemical solution into troughs. Arm continues to invert the bulb and gently deposit it on the screen drying conveyor.

AUTOMATION TODAY

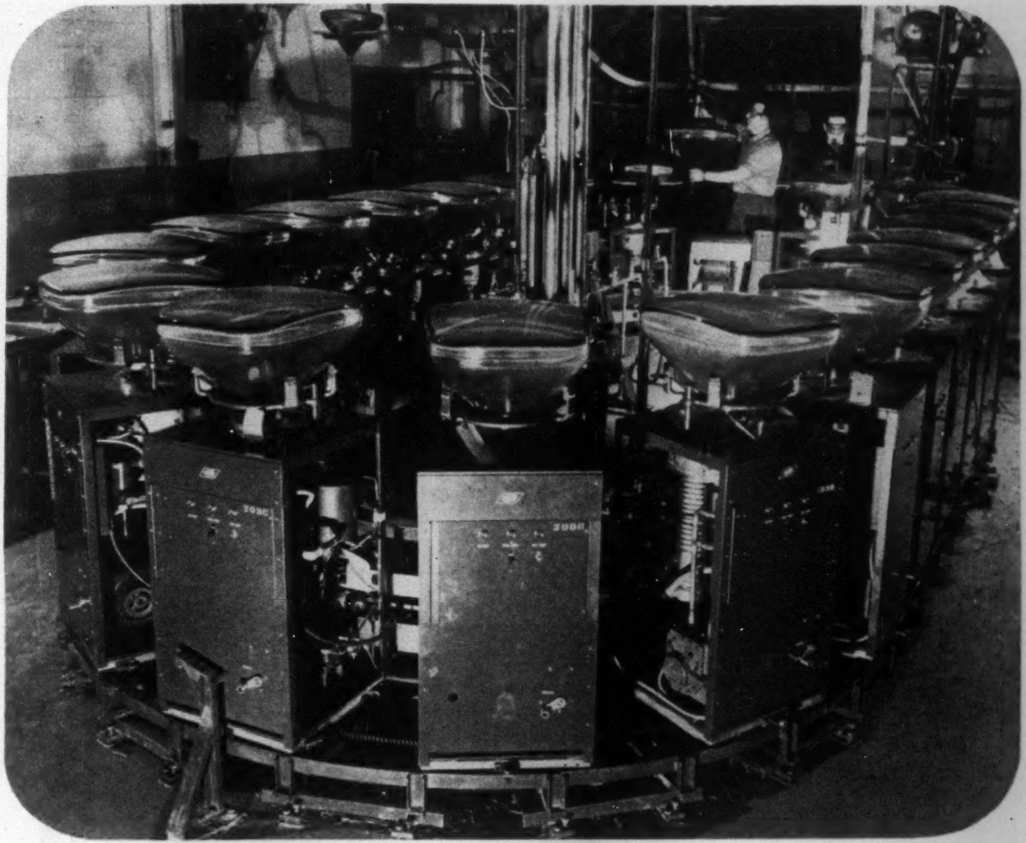
2 Quality control must be maintained. Before any television picture tube is aluminized the faceplate of each tube is inspected thoroughly at this station on the conveyor line. Inspectors check for flaws such as specks or imperfections in screen or glass.



TO SATISFY the preponderant demand among receiver manufacturers and the general public for aluminized television picture tubes in black-and white sets, the television picture tube division of Sylvania Electric Products Inc. has established automated facilities to make possible the production of an additional 25,000 large size aluminized tubes each month.

The process employed results in a product which gives increased light output to the viewer by approximately two to one over nonaluminized tubes, and results in improved picture contrast.

To accomplish this a thin lacquer film is stretched



3

Operator removes tube from conveyor and loads it into position on one of 20 carts on a continuously moving train. Each cart contains a mechanical pump, a high vacuum diffusion pump, valves, and electrical equipment. At the start of the cycle the mechanical pump operates alone for 4 to 5 minutes. As the cart passes the trip arm shown in left foreground the lever is actuated to open the valve over the diffusion pump to provide 4 to 5 minutes of high vacuum pumping.

ALUMINIZING TV TUBES

across the rear surface of the phosphor screen, as a water cushion is carefully poured off. A small amount of very pure aluminum is attached to a tungsten filament on rods inside the bulb and then a vacuum is created. The tungsten filament is electrically heated, so that the aluminum vaporizes and condenses on the inside walls and face of the bulb. In a subsequent process the lacquer is baked out leaving a conductive and mirror film of aluminum.

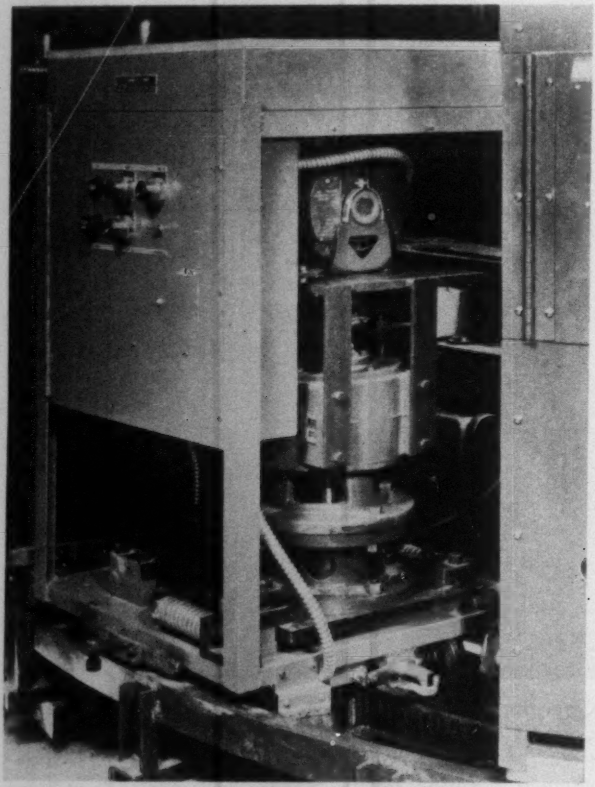
The aluminum coating acts as a light reflector for the light produced in the screen, and causes that part of the light which formerly dissipated itself into the funnel portion to be directed forward toward the viewer.

As television picture tubes became larger, and hence heavier, it was deemed necessary that machinery handle the bulk of the glass bulb transfer work. Now, large automatic suction arms, capable of lifting 500 pounds, pick up the bulbs at important transfer points and place them in position for the various complicated processes. Elevator and elaborate tube conveyor belts also lend to the automation of the new plant.

Some 400 limit switches, 200 relays, 75 timers, 100 motors and 80,000 feet of control wire have been used in the precise synchronization of the tube conveyor system. Power supplies range from 6 volts to 35,000 volts. Motors vary from 1/100 hp to 125 hp in size.

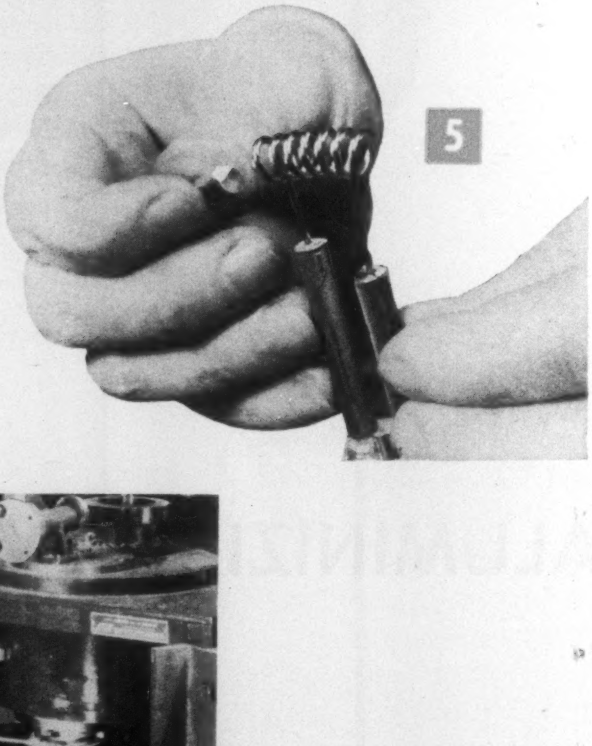
The new automatic and semiautomatic equipment at this plant includes new bulb washing machines, screen settling belts, screen lacquering belts, in-line aluminizing machines, mount sealing machines, in line, rotary, and straight-line exhaust machines, aging conveyors, and automatic test equipment. In addition, an extensive system and elaborate equipment for the control of water temperature has been installed. The majority of production areas are now air-conditioned with the screen production area 100 per cent air-conditioned.

4



Carts on the vacuum metallizing train are pulled by this power unit. Positive motion without slippage is provided by a pinion meshed with a large oval rack below the carts. Shock absorbent couplings that minimize jolts during startup consist of heavy coil springs and a few links of large roller-type chain.

In this process a small amount of aluminum is attached to a tungsten filament which is mounted on two rods inside the bulb. After the vacuum is created the temperature of the filament is increased and the pure aluminum melts, then vaporizes. This vapor condenses on the inside walls and face of the bulb, and becomes a conductive and mirror film.



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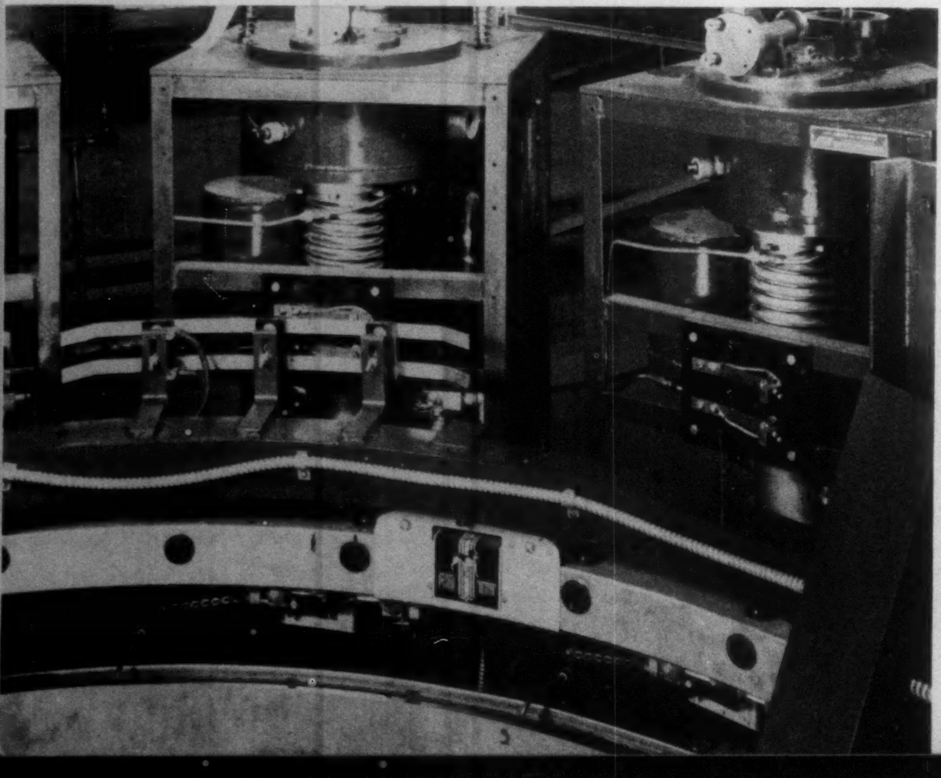
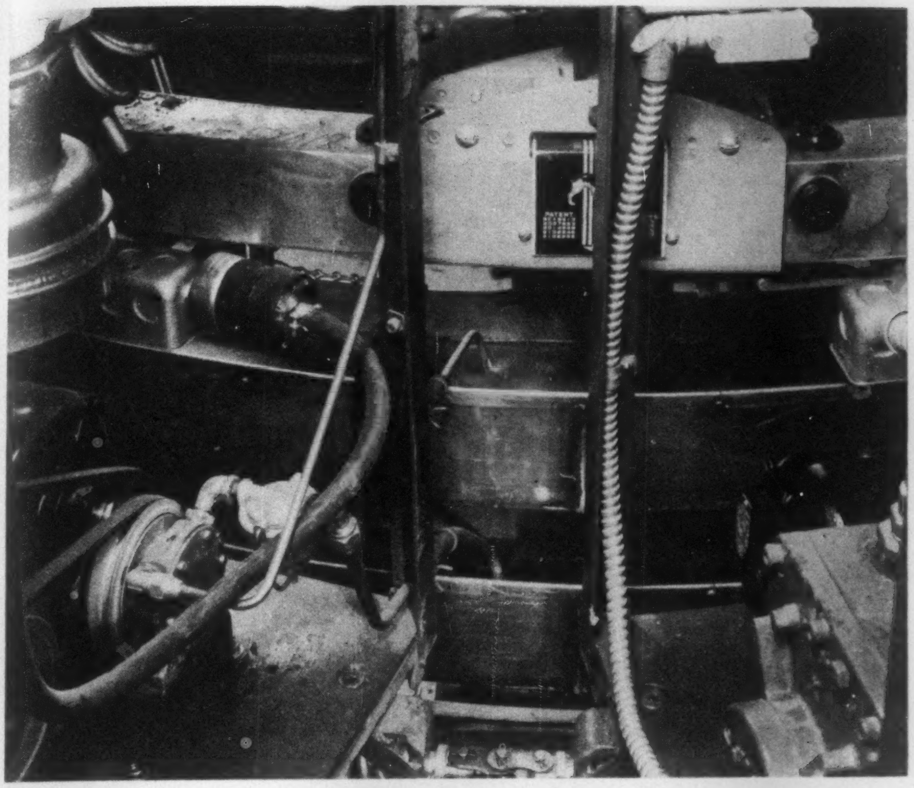


6

Sequencing of actions of the cycle performed by each cart is accompanied by devices mounted at the proper position along the track. Here power bus bars provide current for the vaporizing filament for each cart in turn as it passes.



7

Cooling water for the diffusion pumps is supplied to each cart by a system that includes two gutters around the entire periphery of the track. Water is drawn from the lower gutter and discharged into the upper gutter. Shown above the upper gutter is the power duct that supplies line voltage to each cart through chain towed trolleys.

8

Here the actual aluminizing process of TV picture tubes is taking place on the automatic in-line aluminizer. The aluminum film behind the screen acts as a reflector for the light produced in the screen and thus increases the light output from the receiver by approximately two to one over non-aluminized tubes. In addition this mirror surface prevents scattered light inside the tube from falling on dark portions of the screen, and thus improves contrast. The vacuum metallizing equipment shown was designed by the Consolidated Vacuum Corp.

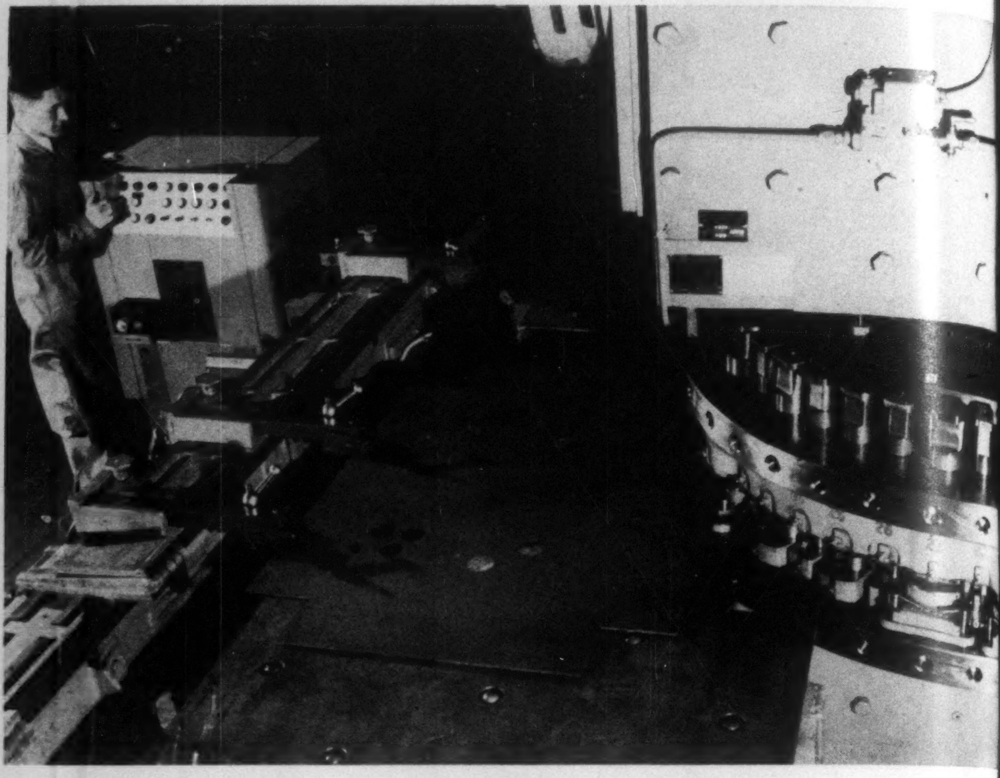
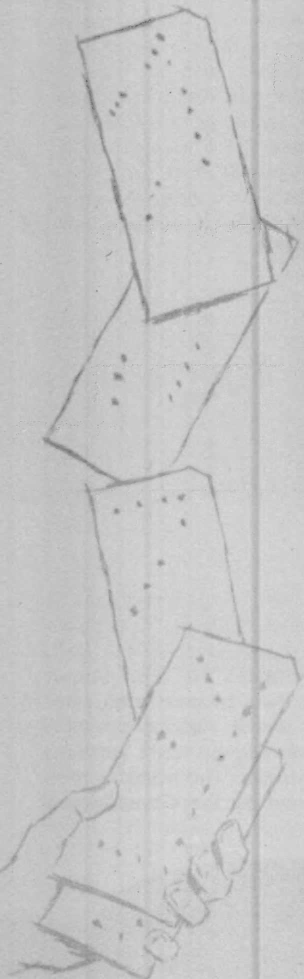


Fig. 1—Operator starts rotary turret punch press which positions itself and carries out punching operations according to card directions



TAKE A CARD FOR

MACHINE TOOL CONTROL

D. B. SCHNEIDER
Electrical Engineer
Specialty Control Dept.
General Electric Co.
Waynesboro, Va.

Broad implications of automation are illustrated by a machine tool control using standard business machine cards as the controlling element. The traditional separation between office and factory is fading

VARIOUS DEVICES developed to program operation of machine tools are most likely to find acceptance in areas where versatility in output rather than uniformity is typical. Program control has its forte in an ability to change pattern or product configuration, not in single product repetition. Obviously, medium and short-run lots have these characteristics more so than "Detroit automation."

An automatic control which uses punched business machine cards to control machine tools has been developed by the General Electric Co.'s Specialty Control Department. Called Numerical Positioning Control, the new system is adaptable for use on a wide variety of machine tools including riveting machines, placement machines, milling, boring and drilling machines, punch presses, lathes and shears. Its immediate application is on a Wiedemann 80-ton turret type press used to punch holes in panels for control boards, *Fig.* 1.

The control reads positioning instructions from punched holes in standard business machine cards. These readings are converted into positioning signals which direct the machine to the correct machining location. This is done through a system of command and pick-up selsyns. When the first card is read, the machine positions itself accordingly and the machining operation takes place. Then the next card is read and the machine moves to its next position. Tool instructions are also read from the punched cards in co-ordination with the positioning movements.

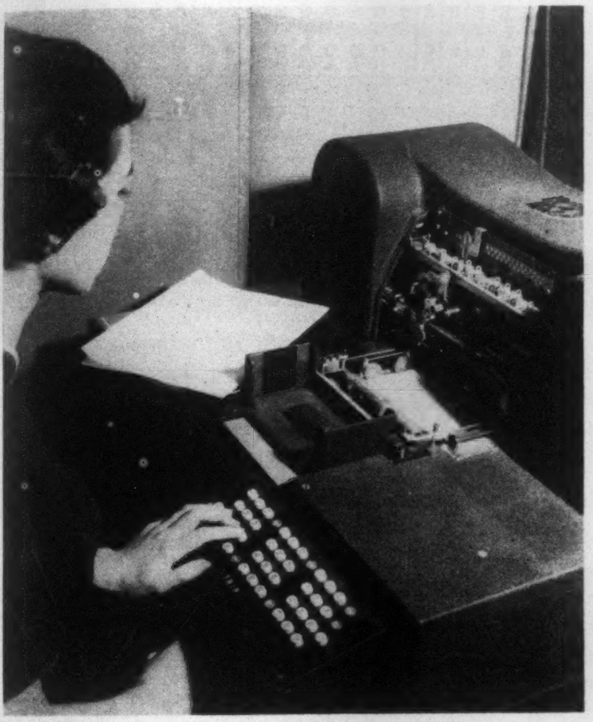


Fig. 2—Standard business machine cards are punched in decimal form uncoded and can be read directly

Normally, the machining operation would take place immediately after the machine reaches the correct position—while the next card is being read. In some applications, however, such as on a lathe, machining occurs during the positioning motion. Therefore, if desired, the machine action may also take place before the positioning is completed.

Standard card processing equipment, *Fig.* 2, is used for punching, sorting and stocking. Positioning information is punched into the cards in decimal form and is not coded. This permits the operator to read directions directly from the card. Each card, as it is placed into the standard card reader, contains complete information for at least one machining operation. The cards also have adequate space for a considerable number of miscellaneous directions, such as operator's instructions, for a variety of machine functions. Machine instructions that would normally be programmed include tool selection and indexing, sequencing of operation and initiating of automatic material handling cycles.

Once the cards are correctly punched and placed into the machine, the operator has only to push the start button and the machine automatically runs through the sequence of operations required. It directs the machine motions and initiates all machining operations until the workpiece is completed. A signal may be provided to inform the operator if manual operations are to be performed.

Consisting of a director, *Fig.* 3, control panel position selsyn pick-up units and dc motor drives, the new control can be built to approach the desired positions from the same direction regardless of direction of travel—materially reducing positioning error caused by backlash. All positions are measured from a zero reference point rather than from a previous position to prevent any possibility of cumulative position error.

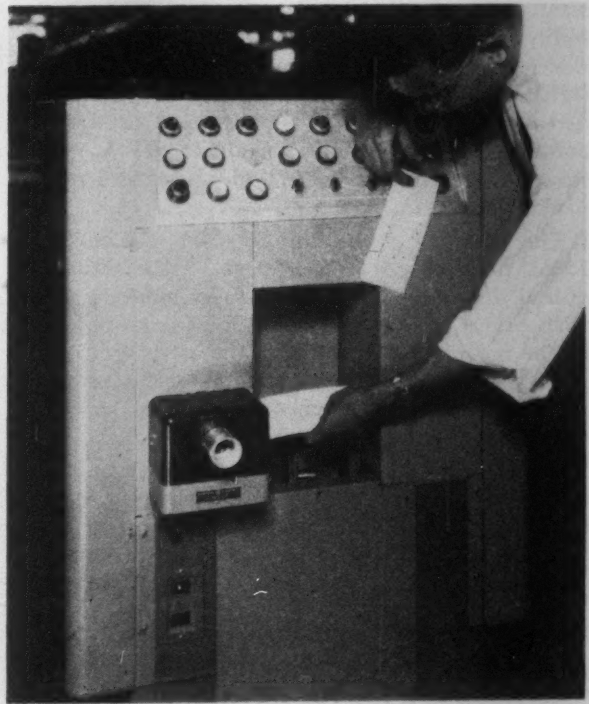


Fig. 3—Operator places cards into reader of director unit. Using the control panel any required special manual operations can be indicated. The photoelectric relay stops the machine if the beam is interrupted while the system is being automatically operated

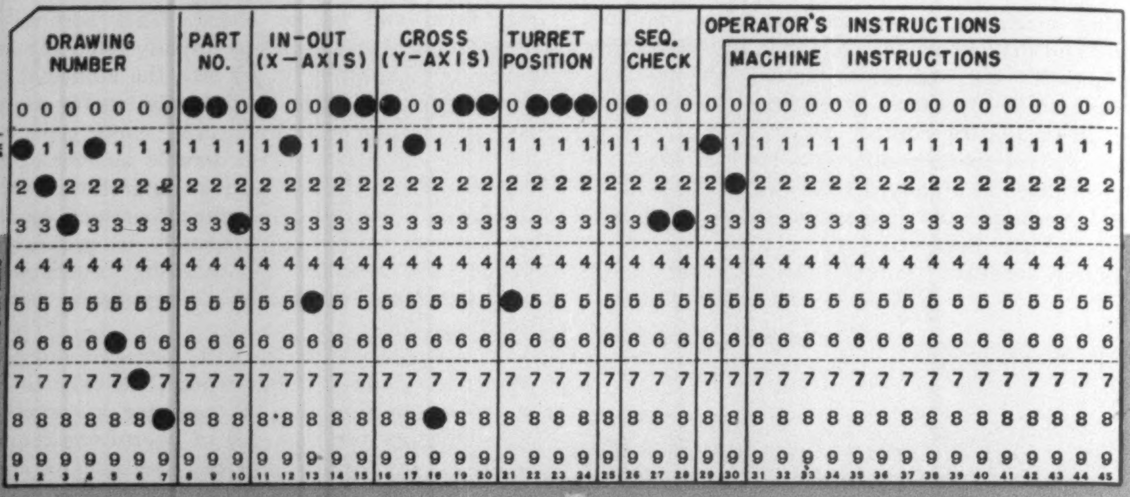


Fig. 4—Standard business machine card which has been punched for numerical positioning control operation. This card is for part number 003 on drawing 1231678. The card will direct the machine to position the (X) axis at 15.00 inches, the cross feed (Y) axis at 18.00 inches and the turret position at 5000. This is card number 33. Operator's instructions 1—machine instructions 2, are called for

▶ Press System Operation

To accomplish punch press control the system must have a means of data storage; a means of interpreting the data; a method of indicating position; control circuitry for checking and amplifying signals; and the required power drives. Power drives used are dc gear motors, and because the horsepowers required are small (1/3 to 1/2) half-wave thyratron control with armature-voltage feedback is used.

The form of data storage used is Remington Rand tabulating cards, *Fig.* 4. Information required for positioning the three motions, along with other information pertinent to the operation of the machine, is punched in the cards by a standard key punch. Positioning information is in digital form and the uncoded decimal system is used.

Information on the card is read through the action of the card reader. A card from a deck in the feedhopper is automatically fed into the reading box where mechanical pins push through any holes punched in the card and become locked. This mechanical stroke operates switches as required for the machine functions and transfers mechanical motion to other locations. Each digit in a position column may be represented by a selsyn which is accurately positioned through the mechanical reading of the card information.

Thus, a digital array of analog units is used to interpret the data. Numbers containing more digits are obtained by merely adding another selsyn. The number of useful digits is limited, as in other digital systems, only by the mechanics performing the transformation. Consequently, this system offers all the accuracy of the best digital systems, yet allows the convenience of the analog systems. Furthermore, by gearing the selsyns, information punched on the cards may be multiplied or divided.

As each card is fed into the pin box all command selsyns are rotated to a chosen starting point (approximately one full revolution from their zero position). After the card is read the selsyns return toward their zeros until they strike a stop which has been selected from the card information. These stops are located at ten equal points throughout a selsyn revolution representing digits 0 through 9. Hence, the selsyns are individually positioned to one of ten points in a revolution. However, if a stop should fail to be set the selsyn will continue on around until it strikes a *Fail to Read* switch which will automatically stop the action.

Although each command selsyn is individually positioned by the reading mechanism, these mechanisms are mechanically interconnected in such a manner that selsyns representing the smaller parts of a number react on the selsyns representing the larger parts. In order to remain digitally correct the gearing used for this interconnection has a 10:1 ratio. Since there are three command selsyns there must also be three position selsyns for the one motion. However, different motions may require different numbers of selsyns depending on the accuracy, speed, and length of travel.

Position selsyns are normally connected directly to the motion so that any backlash or windup in the drives is inside the servo loop. Yet, in this particular installation the selsyns are geared to the shaft carrying the pinion which drives the racks on the table motions, *Fig.* 5. Thus, some of the backlash is outside the loop.

Since each position selsyn is matched to a command selsyn which represents a definite decimal part of a number, the position selsyn must represent decimal lengths. In this installation the lowest speed selsyn is geared for one revolution per 1000 inches travel; the second, one revolution per 100 inches; third, one revolution per 10 inches; and the fourth, one revolution per inch. If greater accuracy were required another selsyn could be added for one revolution per 0.1 inch.

Each card determines one complete machine cycle as all three motions (X axis Y axis and turret position) are punched into one card and read simultaneously. Since each motion constitutes a complete system in itself, all three motions position at the same time. Depending upon the distance to be traveled the various motions reach completion at different times. To insure that the punch cycle will not begin until all motions have stopped, an error monitoring circuit is included. This prevents the punch from operating as long as any motion is not complete. The machine contains both top and bottom turrets which are driven by the same motor but by separate chains on individual shafts located on the same axis. To insure that these turrets are perfectly aligned it is necessary that locking pins be used. As soon as all motion has ceased and the turret locking pins are set, the punch cycle is initiated through action of the error monitoring circuit. At the same time the card fed cycle is started. Consequently, while the machine is in the process of punching, the next card is automatically being fed into place and read for the next punching operation.

During the punch operation the selsyns are deenergized and the motor control loop contactors are opened so that no motion can take place. This becomes necessary because the command selsyns are being positioned for the next operation.

▶ Operation Planning

In planning a deck of cards for punching, a particular pattern must be followed. Since, in this application, clamps hold the material in place it is necessary to be sure that no position called for coincides with a clamp position. This planning is done when the cards are prepared so that the sequence of events is known. The clamps may then be moved at the proper time or the material turned to prevent interference. This requires that the cards be read in a given sequence and so a sequence check is included. As each card is read, its sequence number is noted and compared with that established by the card reader. If the card should be out of order the machine stops and an indicating light informs the operator of the difficulty. By reading the cards in a definite order the machine operation may be halted at specified points.

Although essentially an electronic control there are more relays and contactors than there are electronic tubes—approximately 80 relays and less than 50 tubes. The large number of relays and contactors are necessary to perform such functions as card sequence checking, card feed and other error monitoring, in addition to various other machine functions. The control is capable of various applications and little machine modification is necessary to adapt it for use. Its main application, however, will be by machine tool manufacturers who will apply it directly to their machines, rather than to install it on already existing equipment.

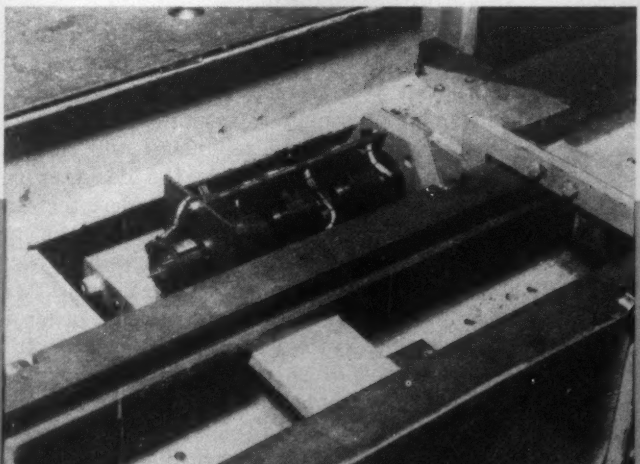
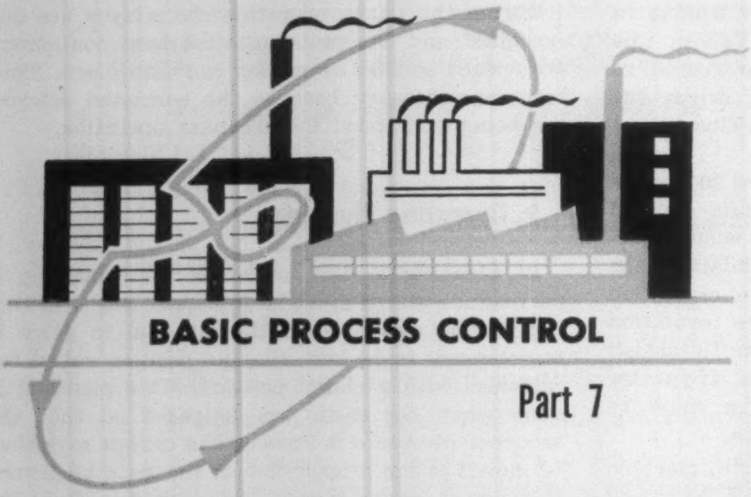


Fig. 5—Selsyn pickup unit in numerical positioning control installation on an 80-ton punch press. This pickup is used for automatic measurement of table position



Part 7

SYSTEM APPROACH

THE COMMON LANGUAGE OF CONTROLS

By **C. W. WORLEY**
Application Engineer
Brown Instruments Div.
Minneapolis-Honeywell Regulator Co.
Philadelphia, Pa.

Methods presented in this series of articles are not restricted to the design engineer but have great utility in performance evaluation and even in maintenance. As these techniques become more widely used, the gap between those who develop and manufacture controls and those who use them will be narrowed

IT IS APPARENT that the feedback control techniques outlined in this series of articles are important tools for the engineer in the design of automatic control systems. Use of these techniques in the design of a process control system can result in increased production and an improved product quality as well as reduction in, or elimination of, unscheduled process shutdowns. Their use also offers a means whereby prediction of performance can be made so as to enable the user to select equipment which is most desirable for a particular application. New processes can be "started up" with more assurance that they will perform satisfactorily.

General use of these techniques in the process control field will lead to a uniformity of thinking in that it will simplify the problem of communication by providing a "common language" understandable by control engineers and process engineers alike. It will enable the designer to determine the cause of undesirable side effects or process disturbances, and to eliminate or minimize these effects. It will make it possible to establish the necessary response characteristics which an instrument or process must have in order to make the complete system operate as desired. It permits a comparison of the performance of various processes and components where a number of choices are available.

There are, therefore, several general areas where feedback control theory may be used to advantage: (1) System design stage, (2) device performance evaluation, (3) system trouble shooting, (4) system evaluation of future instrumentation, and (5) industrial management problems. A brief discussion of each area will serve to place emphasis on the practical use of these techniques.

▶ System Design Stage

Throughout all industry today there is a steadily increasing trend toward high-speed continuous processes. The oil industry can be cited as an example of an industry which has benefited by this trend. In the early twentieth century petroleum refining consisted substantially of nothing more than separating kerosene from crude oil. Even in 1913, when the first thermal cracking unit was placed in operation, refining was a simple batch process, essentially manually controlled. One has only to contrast these units with the modern continuous processing combination units and their complex control panels to measure the impact of this trend on this particular industry. It is safe to say that without automatic control the industry could never have reached its high level of productivity for the amount of dollars invested.

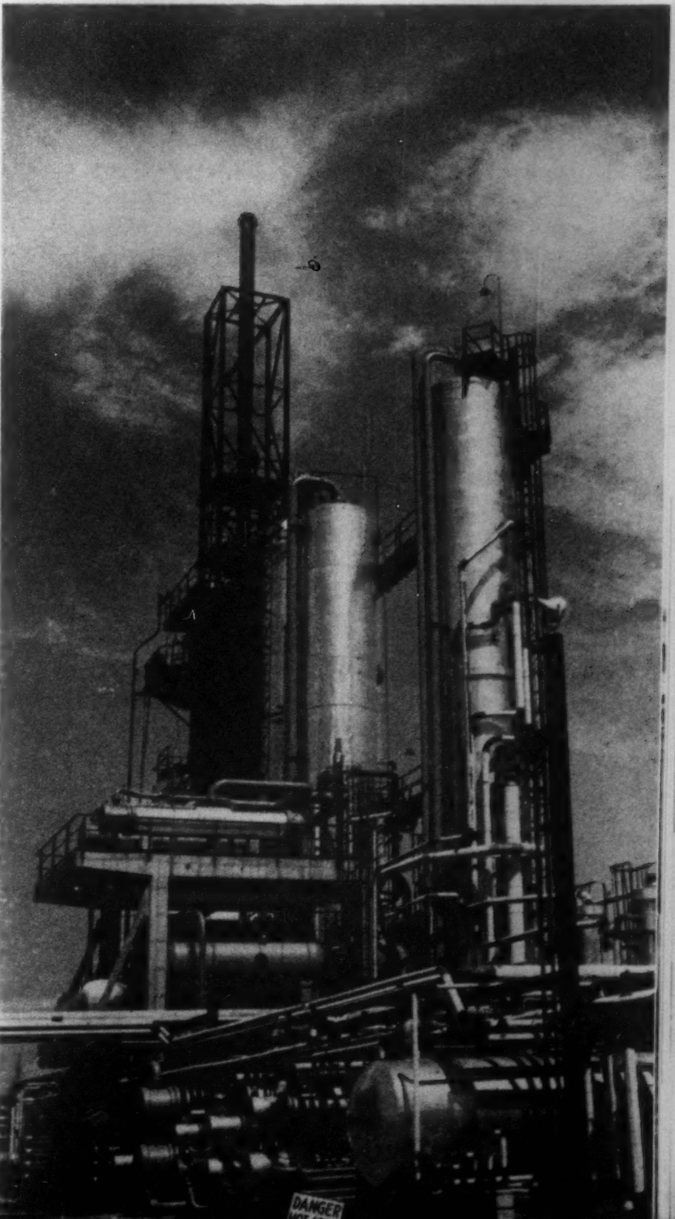
Increased throughput afforded by continuous processes places exacting demands upon the control of process variables and since product quality must be maintained, a high-performance control system is required. Process variables such as temperatures, pressures, and flows must be held under very rigid control. Often, these variables are closely interrelated so that a fluctuation in one will adversely affect the others, and consequently, the entire process. Such a process upset can result in the production of a large volume of an inferior quality product—or even in shutdown of an entire plant. In such a case, close control of process variables means the difference between success and failure as far as the processor is concerned.

Automatic control is, therefore, no longer a luxury in the process industries. On the contrary, successful incorporation and use of automatic control is often vital to the operation of the process. Heretofore, most processes and processing equipment have been designed with little thought to the type of control that will be needed to regulate process variables so that the process will consistently turn out a high quality product at an economical cost. Control components and associated equipment have sometimes been regarded as necessary evils which somehow must be added to the process. Experience has indicated that this is an unwise and often costly attitude. If the capacities of control are to be fully realized it must be considered early in the design of the process. Using feedback control theory as a tool, it is possible to fit the process and control system together analytically.

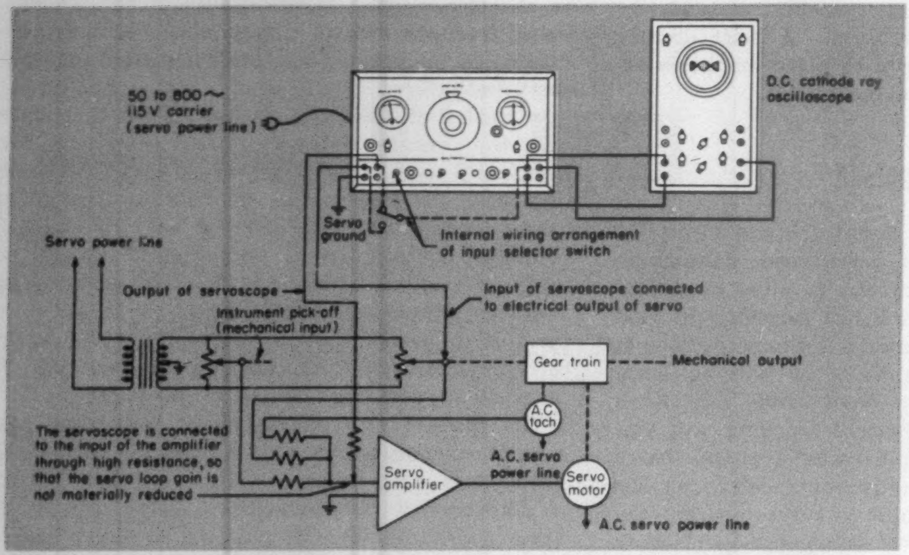
In Part 2 of this series it was shown that since both the process and the control equipment are essentially energy storage or transfer devices, they can, for purposes of analysis, be treated in the same manner. In Part 3 it was shown that feedback control theory furnishes a means of equating the two. Not only can this equating be done analytically, but still more important, it is possible to assign specific performance figures to the complete system, thereby assuring selection of the system providing the best performance.

The process with its associated measuring and control components is broken into its component parts, each part isolated and studied individually to determine its characteristics. Using the procedures illustrated by the analysis of the pressure control system, the individual component characteristics are combined into the system character-

Courtesy, Minneapolis-Honeywell Regulator Co.



The oil industry can be cited as an example of an industry which has benefited from the trend toward high-speed continuous processing


50 to 800 ~
115 V carrier
(servo power line)
D.C. cathode ray oscilloscope
Servo ground
Internal wiring arrangement of input selector switch
Servo power line
Output of servoscope
Input of servoscope connected to electrical output of servo
Instrument pick-off (mechanical input)
Gear train
Mechanical output
A.C. tach
The servoscope is connected to the input of the amplifier through high resistance, so that the servo loop gain is not materially reduced
A.C. servo power line
Servo amplifier
Servo motor
A.C. servo power line

Courtesy, Servo Corp. of America

Test arrangement of equipment to measure frequency response data

istics. From this analysis, the overall performance can be predicted, and appropriate changes made in the early stages of the system design.

Assume that several alternate systems are proposed. Since the designer can evaluate performance of the systems numerically, he is able to select that system which will most closely suit his requirements. Perhaps he discovers that none of the proposed systems will fulfill his needs. There are several alternatives still available; he may decide to seek different types of controllers or control equipment, or to redesign his process—whichever choice is economically feasible.

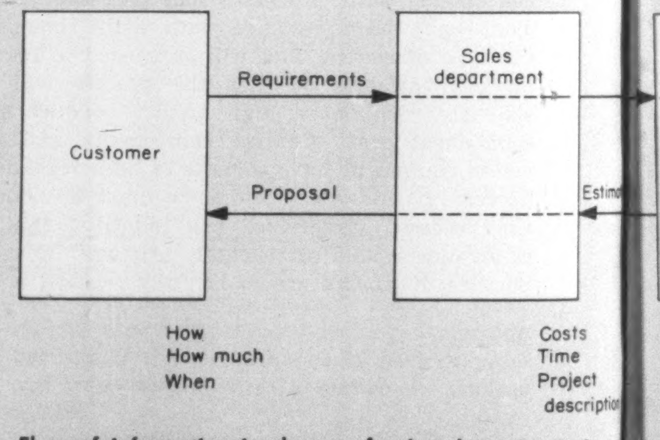
▶ Device Performance Evaluation

Techniques just described are also useful in evaluating the performance of devices. The word device need not necessarily be construed as being limited to instrumentation, since the approach can be used equally well on a process or a piece of processing equipment. However, since most processes are designed initially to do a specific job in producing a single product, most evaluations will be confined to system accessories, such as control instruments and valves.

By means of the feedback control techniques, the control engineer is able to accurately define the dynamic requirements of the system components. After determining his requirements in this respect, such as accuracy, sensitivity, lags, and similar characteristics, he can then evaluate the dynamic performance of various available components and select those which most nearly satisfy his requirements.

While frequency response testing is an extremely useful tool for evaluating dynamic performance, the engineer should be thoroughly acquainted with certain fundamental premises before he attempts to interpret the test data and to select components based on predictions arrived at from this information.

These fundamental premises which enter into the validity of the tests include: (1) Obtaining data on components under realistic test conditions; (2) careful selection of measuring points and test equipment; and (3) interpretation of the data in the light of previous practical experience. The reason for these qualifications is fairly obvious. Unless tests on components are evaluated in the light of these factors it would be quite possible for the test data to show that one component was superior to another, when in reality the difference in the dynamic performance of the two resulted.


Customer
Requirements
Sales department
Proposal
Estim
How
How much
When
Costs
Time
Project
descriptio

Flow of information is always of prime importance to any organization. Each block represents an area where some transfer of "energy" takes place

Courtesy, Square D Co.

The engineer familiar with feedback control techniques has a definite advantage in trouble shooting control systems

not from inherent differences within the components themselves, but rather from differences in test conditions. In this respect, the limitations imposed upon frequency response testing are no different from those imposed upon any other kind of tests that are performed to establish the comparative merits of equipment.

▶ Trouble Shooting

Perhaps the most useful area at the present time where these techniques are of immediate value to industry is in trouble shooting a system which is already in operation, but which is not performing satisfactorily. Since it seems to be a natural human instinct to avoid the use of something new until every other available means has failed, this is actually the first area in which these techniques were employed.

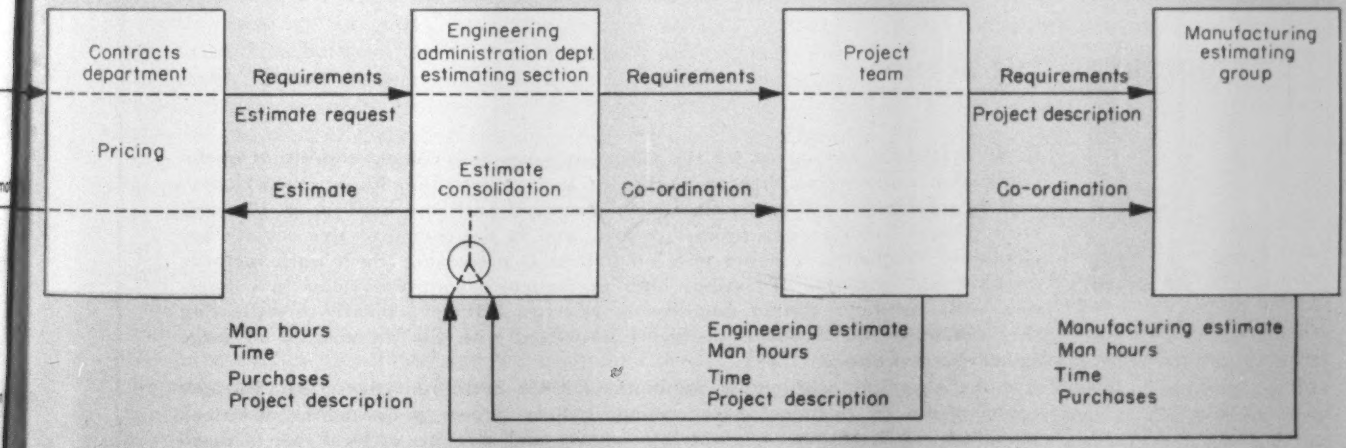
System trouble shooting may or may not require a detailed analysis of the control system. It would, of course, be economically undesirable to apply these techniques to the solution of any and all process control problems. It is obvious, however, that the engineer familiar with these techniques has a definite advantage in trouble shooting control systems. A basic familiarity with the general operation of common system components afforded by previous analysis of control systems furnishes a useful background for the instrument engineer. Ability to interpret the transient recovery curves of the system in the light of system configuration often leads to a quick discovery of the poorly performing component. On those applications where the dynamic performance of the system is critical for the successful manufacture of a product, this approach is not only the most useful, but, in many cases, supplies the only satisfactory solution to the problem.

▶ Evaluation of Future Instrumentation

Today, everyone is familiar with the predictions of the pushbutton plants and automatic factories of tomorrow. Obviously, the erection of such plants will involve tremendous expenditures of both manhours and capital. It is equally obvious that there is no place for costly trial-and-error methods in the designing and construction of these plants with their complex interrelated processing equipment.

Feedback control is one of the essential tools that must help to bring about these advances in

Estimating procedure at Arma Div. of American Bosch Arma Corp.


Contracts department
Pricing
Requirements
Estimate request
Estimate
Engineering administration dept estimating section
Estimate consolidation
Requirements
Co-ordination
Project team
Requirements
Project description
Co-ordination
Manufacturing estimating group
Man hours
Time
Purchases
Project description
Engineering estimate
Man hours
Time
Project description
Manufacturing estimate
Man hours
Time
Purchases

industrial processing. Before systems such as end-point control can be realized, it is necessary to know exactly how the process will react under any condition of load or disturbance. How can a computer calculate the necessary data to insure product quality, if the control of variables being fed into the computer are not stabilized?

Application of feedback control theory will permit a complete analysis of these complex systems before they are designed and installed. As previously pointed out, through use of these techniques it will be possible to set down the basic functions required of the computer in a language that is understandable, not only to the control engineer, but also to the process and equipment design engineers.

There is still another use for these techniques in the development of such systems. Through the use of analogs, it is possible to investigate several solutions to a particular problem without the capital investment that would be required in the case of models, pilot plants, and field tests. In a problem of quality control of a product, for example, the only complication would be that of proper sizing of the analog, and even the working out of this detail will be aided by feedback control theory.

▶ Industrial Management Problems

Although normally considered as having application only with respect to inanimate objects such as industrial processes and control components, feedback control theory has no such limitations. In fact, the solution of industrial management problems is perhaps the most intriguing area of application of these techniques.

There exist certain marked similarities between physical systems and industrial organizations that can be used to advantage in a study of these o ganizations. For example, in any industrial o ganization there is a certain amount of transitio time, or dead time, just as there is in a physica system. The operation of integration in a com puter or other instrument can be likened to tha section of an organization where a summation o information takes place. Other similarities exis which make it possible to construct a working analog.

Since, in such a study, the flow of information is always of prime importance to any organization, the block diagram concept can be used. Each block in the diagram represents an area where some transfer of energy (such as transition from a management order to a completed project) takes place. Often, the block diagram is similar to a flow sheet of the organization, since most information flows from one level of authority to another.

This particular area of application of feedback control theory is at present receiving much attention in the field of management consulting as part of the broader field of operations research. Although it is relatively new and requires a radical departure from present thinking, it has shown great promise for certain specialized problems.

In this series of articles an attempt has been made to show, briefly, the basic fundamentals of feedback control as applied to the design of process control systems. Recognizing that, for many, the subject has been difficult to grasp because of language barriers, an effort has been made to cover the subject in readily understandable terms. It is hoped that this material will aid in reducing the gap that exists between the systems engineers and control manufacturers who have developed the instrumentation devices, and the managers and production engineers who must make use of control. Only by close co-operation between the two will there be a complete realization of the possibilities of closed-loop feedback control.

THE AUTHOR

C. W. WORLEY has served for the past four years as a control consultant in the application engineering division at Brown Instruments Div. Minneapolis-Honeywell Regulator Co. Here he has been concerned with the application of feedback control techniques to process control, and in the course of this activity has conducted frequency response tests on industrial processes. Such work includes analysis and synthesis of various high performance control systems in connection with customer system engineering activity. He is presently investigating the economic and technical problems associated with the automation of large industrial processes.

An electrical engineering graduate of Ohio State University, Mr. Worley's contributions to technical advancement include papers presented to electrical, chemical and instrument engineering societies and speeches at local society meetings.

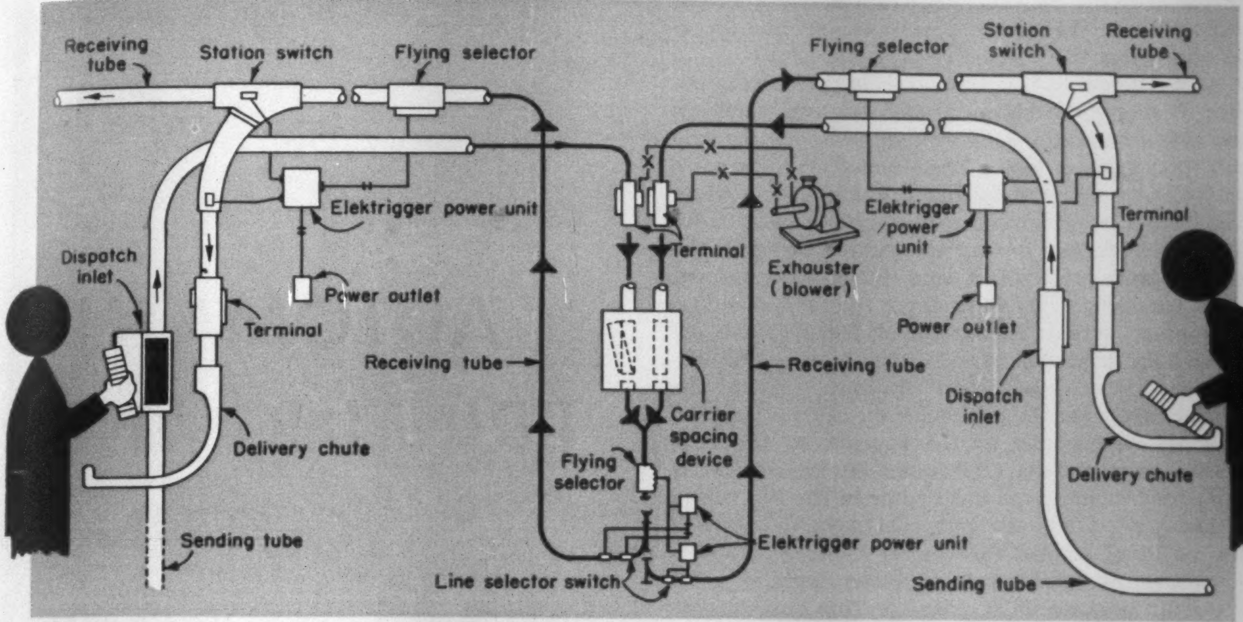

Receiving tube
Station switch
Flying selector
Flying selector
Station switch
Receiving tube
Elektrigger power unit
Dispatch inlet
Power outlet
Terminal
Terminal
Exhauster (blower)
Elektrigger /power unit
Terminal
Power outlet
Receiving tube
Receiving tube
Dispatch inlet
Carrier spacing device
Flying selector
Delivery chute
Delivery chute
Sending tube
Elektrigger power unit
Line selector switch
Sending tube

Fig. 1—Schematic drawing of the major elements in an automatic air tube system. Rings on the carrier act as electrical contacts for brushes in the selector and close the electrical circuit to actuate the switch corresponding to the address coded by the rings

PNEUMATIC TUBE SYSTEM UPDATED

WITH ELECTRIC SWITCHING

PNEUMATIC tube communications systems are familiar to most department-store customers as links between the sales clerks and a central desk. These systems provide only two-point communications—each station can send and receive to the central desk but cannot communicate with another clerk except through manual transfer at the central desk. The mass of tubing radiating from the central desk attests to the high tube cost and blower capacity necessary for this limited performance.

More versatile communications for modern automatic plants are provided by an automatic switching system developed by the Lamson Corp. composed of two continuous lines for sending and receiving which encompass all the stations in a loop, *Fig.* 1. Each station has both a short length of inlet and outlet by-pass tubing which connect the station to the main loops of tubing. Usually eight stations compromise a loop; where additional stations are required, the system will have two or more loops intersecting at one common point.

Once the proper settings are made on the carrier, *Fig.* 2, it delivers itself automatically to its destination. Three movable brass rings and seven equally-spaced fixed rings are on the outside circumference of each carrier. Two of the movable rings are adjustable to indicate letters which designate loops; the other movable ring indicates numbers which designate stations within a given loop. When the sender dials a particular number and letter, the movable rings become electrically connected to two of the fixed brass rings by the alignment of metal contacts inside the tube. As a result, each coded setting creates a distinctive physical spacing between the brass rings. This spacing indicates to the various selectors in the system how to route the carrier.

When placed in the dispatch inlet, the carrier travels around the loop until it reaches a spacing device that automatically intercepts the carrier and holds it for ten seconds before releasing. This device prevents two carriers from arriving at the same point in the system simultaneously and thereby eliminates the possibility of jams.

After the carrier is released from the spacing device, it moves through a flying selector which, in the case of multiple-loop system, switches the carrier to the proper loop. The selector contains pairs of feelers, each pair having a distinctive spacing. The switch is energized as the carrier passes under the pair of feelers having the same spacing as the pair of brass rings which were connected in dialing.

As the carrier proceeds along the loop, it comes in contact with a succession of feelers, each set located about 15 feet ahead of the by-pass delivery line leading to individual stations. When the carrier arrives at the particular set of feelers whose spacing corresponds to the spacing of the connected rings on the carrier, an electric circuit is completed which trips a deflector in the line ahead of the carrier. The deflector routes the carrier into the receiving line of the station selected; the carrier drops by gravity into a delivery chute, tripping a circuit breaker as it passes. This de-energizes the deflector solenoid and permits subsequent carriers destined for other stations to pass that station.

One of the operating advantages of this automatic system is that the electric controls are local at each station. In the event of electrical failure, the difficulty is located at the particular station affected, saving a considerable amount of trouble-shooting time.

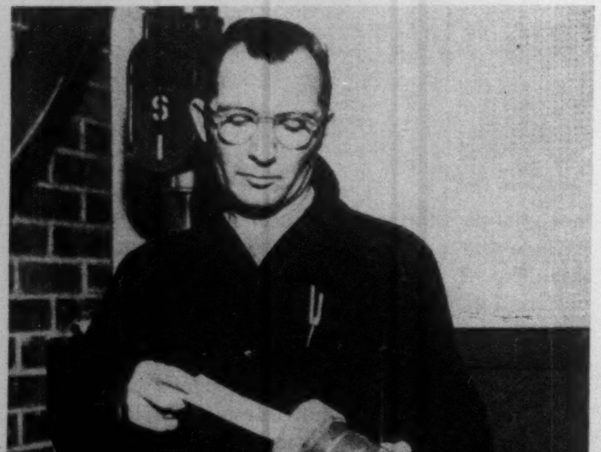


Fig. 2—Carrier used in the automatic switch tube system installed in the Baton Rouge refinery of the Esso Oil Co. to improve communications in maintenance operations. Address is coded onto the carrier by moving the carrier rings

Gillette
BLADE
Gillette
BLADE
Gillett
BLADE

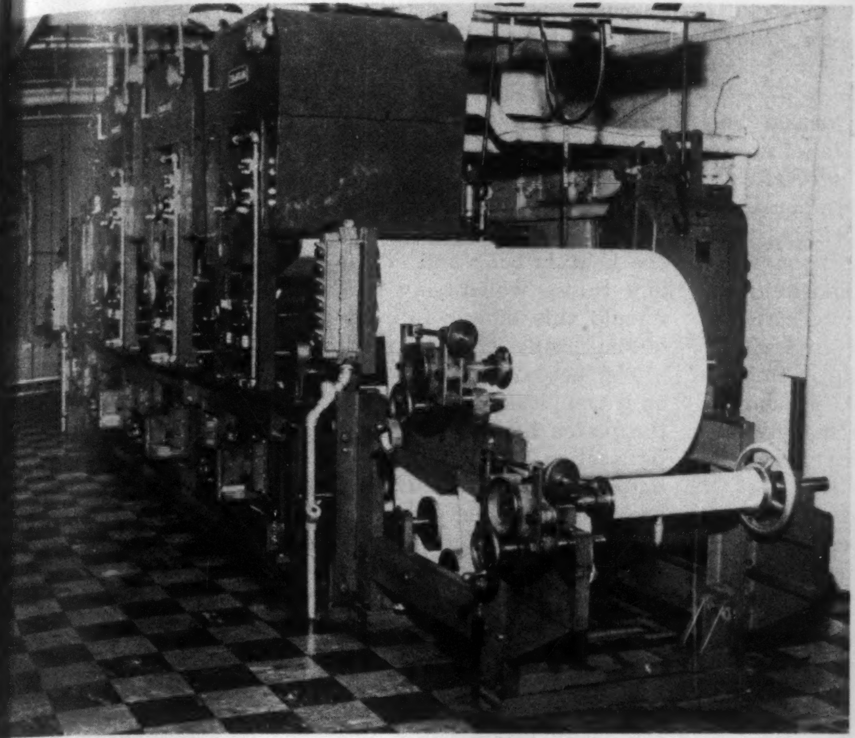
AUTOMATED PRINTING AND CUTTING

PRODUCES RAZOR BLADE ENVELOPES

Production of small items is often big business. Manufacture of envelopes to package razor blades is automated on this in-line installation to economically supply the volume required

FORTY-FIVE MILLION razor blade envelopes are printed monthly on a new rotogravure press installed at the Gillette Safety Razor Company. This rate of production is accomplished in a normal 40-hour week and at an estimated saving of 35 per cent. Responsible for the high rate of production is the fact that the new high-speed press prints, die-cuts and rewinds in one continuous operation—there is no handling between steps. A major portion of the saving is attributed to the design of the envelope and the fact that re-winding eliminates end waste formerly associated with the cutting and stacking of envelopes. In addition to these advantages, the color and appearance of the finished product are now more satisfactory.

In operation, rolls of supercalendered gravure paper are hoisted onto a roll stand at one end of the press, and the web feeds automatically to the



THIN
Gillette
BLADE
THIN
Gillette
BLADE

Fig. 1—Paper fed to this integrated line by the roll stand in foreground passes through three printing presses, a cutter, and onto 12 reels on the rewinder. Manual handling is not required between operations, edge waste is pneumatically removed, and lubrication is automatic

printing units, through an eccentric die punch and to a rewind unit. All elements of the "in-line" installation are manufactured by one firm—the Champlain Company Inc.

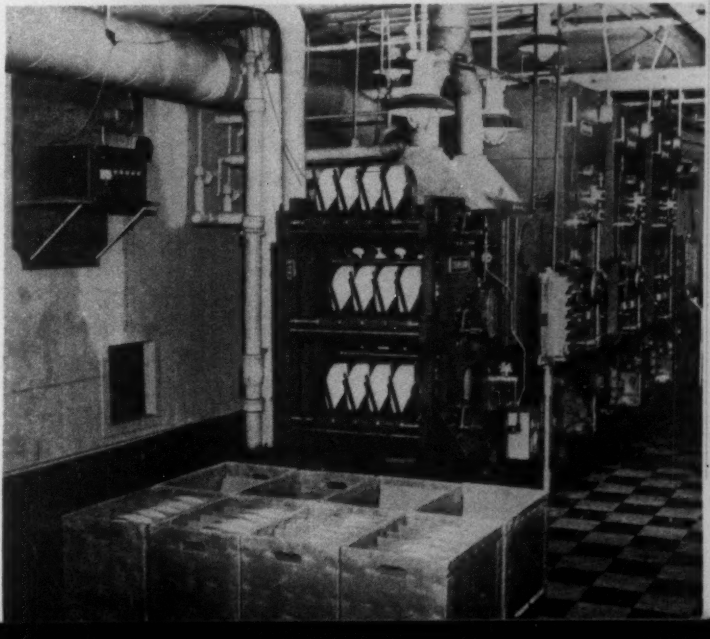
Paper is used in 800-lb rolls 20½ inches wide, and 12 rows of envelopes are printed across the width of the web. Gillette winds 15,000 printed envelopes to a roll and since 12 rolls are printed at a time this amounts to 180,000 envelopes between core changes. Formerly, each individual envelope was cut apart and stacked. Full rolls are removed and empty cores substituted approximately every 30 min. Edge waste is automatically stripped as the web leaves the die punch and is pneumatically conveyed into a waste receptacle.

As the finished envelopes are wound, they are electronically counted and when 14,750 envelopes have been printed a horn sounds and the two press attendants prepare to remove the printed envelopes and install empty cores. This operation is carried out as the 15,000 mark is reached and takes about 1½ minutes. Reels are changed one at a time, one man removing the finished roll, the other putting in the new core and starting the re-wind cycle. Multiple spindle reel stand permits constant operation for each of the 12 spindles. As reels are removed they are mounted on a special rack where they subsequently are marked as to the run and are sealed with tape. Rolls are then placed in cartons for ultimate delivery to the packaging area.

When the rotogravure equipment is operating only one shift, two men are assigned to its operation. These men, incidentally, came from Gillette's print shop although neither had previous experience with rotogravure equipment.

The installation includes three printing units, and so three different inks can be used on a single envelope. Only two of the printing units are used

Fig. 2—Envelopes are electronically counted and operators are warned so that reels of 15,000 envelopes can be removed and empty cores substituted



to print Gillette "Thin" envelopes which require only two colors—red and black. Gillette "Blue" envelopes require three colors—two shades of blue plus the black.

Printing cylinders make up to 1,200,000 impressions before being changed, and it takes about 1½ hours to install a replacement. A special carriage-rack which comes with the rotogravure equipment mounts on the side of the printing unit and the same air hoist which loads the press with paper is used to lift the printing cylinders from the press carriages onto a dolly for removal. At the present time worn cylinders are being stripped of their surface and the copper underlining re-etched. Experimentation is planned, however, in simply stripping the chrome and then re-chroming without re-etching the copper, a practice in other types of gravure printing.

Complete records are kept on cylinder performance, as well as other phases of the operation. For example, microscopic measurements are taken of the depth of etching, width, and wall thickness at numerous points when a cylinder comes in and should these dimensions not meet minimum specifications the cylinder is not accepted. Similar measurements are taken when the cylinder no longer produces desired printing results and comparisons are made with other cylinder runs.

Doctor blades are trimmed when examination of finished work shows the blades need trimming. Blade life may vary from a few days to several weeks. To separate ferrous impurities before they get to the cylinders, magnetic separators have been installed in the ink lines.

The web of paper being printed is supplied to the press from the roll stand at a constant tension provided by a governor roller connected to a variable speed drive. As the web is drawn through the feed unit it partially supports a free-floating dancer-type governor roller, causing the roller to rise as tension increases and lower as tension decreases. As the roller rises and falls it regulates the variable speed drive to operate feed rollers faster or slower to decrease or increase web tension.

Steam heated drying elements dry the ink at each printing unit. A blower circulates air about the heating coils and at the same time draws off any fumes which may be present from the ink. Should this blower fail for any reason the press automatically shuts down.

The eccentric punch moves with the web and as it completes one punching, or cutting operation, the platen lifts and moves back to cut the following section of web as it moves along. Static eliminators are installed before and after the punching operation. Moving parts causing the eccentric motion are automatically lubricated. This type punch is especially designed for use where small items must be produced in large quantities. As the strips leave the punch they are wound on cores mounted on a multiple roll rewind.

Power for the roll stand, printing units, cutter, and rewind is supplied from one 20-hp motor, the roll stand being driven through a variable speed transmission. Although drive power is supplied from one central motor, smaller auxiliary motors position the printing cylinders up and down, forward and back, in response to individual controls. Highly accurate registration can thus be obtained.

This installation is another example of the application of techniques of automatic processing to a simple low cost item. Such cases readily show that operations which can be improved by automation are not limited to processing of complex high cost units.

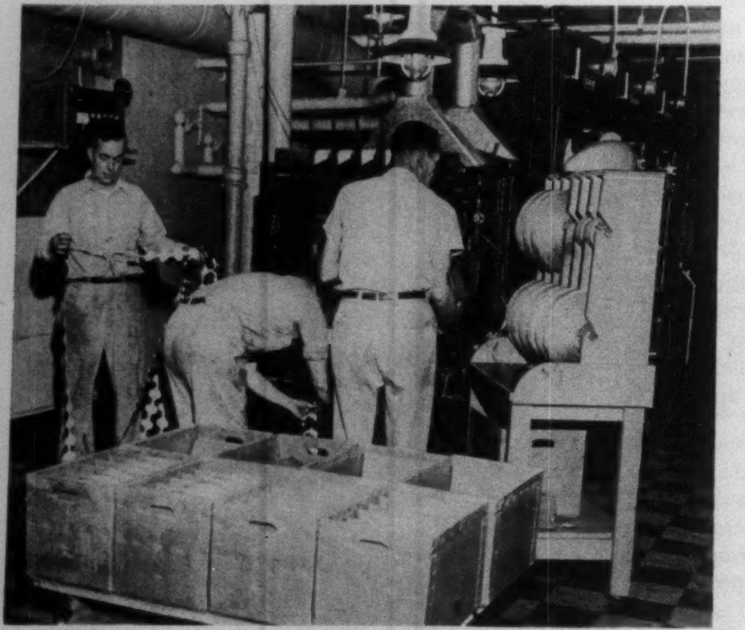


Fig. 3—Two men normally operate this printing line. They supervise its operation, remove full reels, seal the ends with tape and pack the reels in cartons for the blade packaging operations

Effective control specification is based upon intimate knowledge of the process and product. If your particular process involves aqueous solutions—have you considered the physical property of conductivity? Within limitations, it permits the utilization of a relatively simple but accurate means of attaining an automatic control of processing

By **J. B. MOHLER** and **R. ROSENTHAL**
Consulting Engineer
New Castle, Pa.
Chief Chemist
Industrial Instruments, Inc.
Cedar Grove, N. J.

CONDUCTIVITY CONTROL

OF AQUEOUS SOLUTIONS

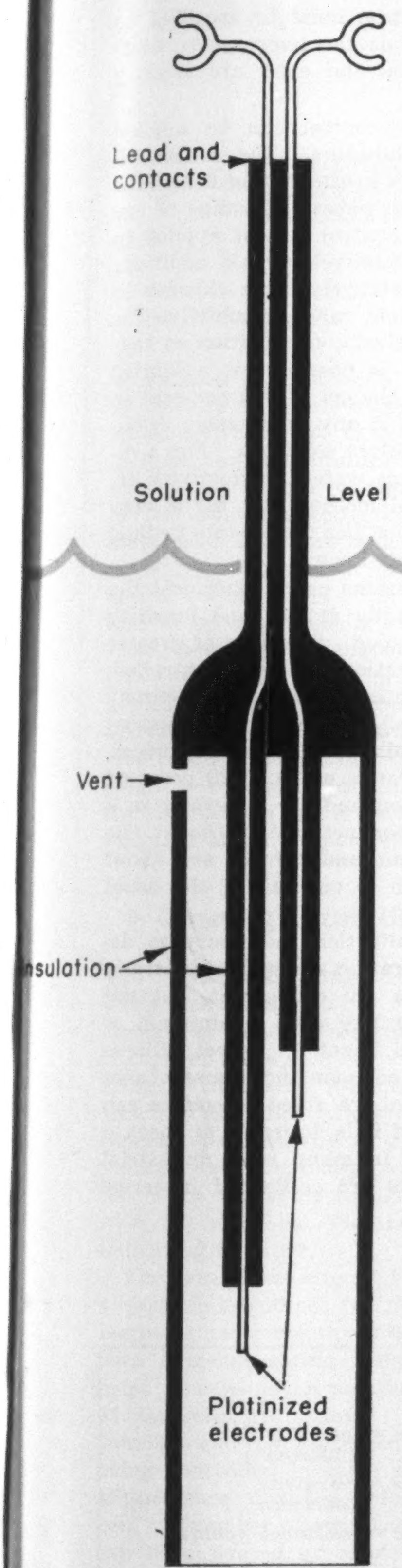


Fig. 1—Cross section of dip-type conductivity cell. Cells are also available as glass laboratory cells for very precise measurements and with water tight fittings for insertion in pipe lines or closed systems

AMONG the many applications of regulation involving analogous measurements is the process control of aqueous solutions based upon the property of conductivity—the inverse of the resistivity of the solution to the passage of an electric current. Not all solutions exhibit an electrolytic characteristic necessary for this type of control but for those that do all ionizable chemicals that are present in the water contribute to the total conductivity of the solution. Thus conductivity can be used as a measure of total chemical or total salt content.

Measurements of the resistance of a confined body of solution follow Ohms law when a current is passed through the solution by means of two fixed electrodes. Consequently, the total resistance for a given application can be measured by means of a Wheatstone bridge circuit. Alternating current must be used in the measuring circuit and conductivity cell to avoid polarization—the concentration of the ions at the electrodes that would take place if direct current were used. It must be kept in mind that total conductivity is measured, i.e., a measurement is obtained which is an expression of the total concentration of all ionizable chemicals. The method will be of practical value where it is desired to measure this total concentration; where a specific chemical is predominant; or when interested in one chemical in a solution, contain-

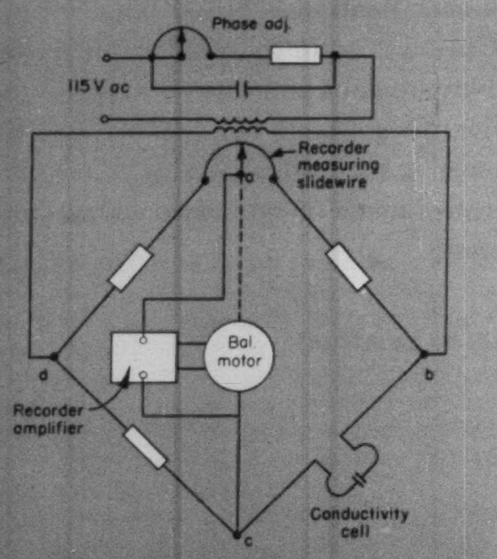


Fig. 2—Diagram of typical indicating-recording circuit. Change in concentration of the solution appears as resistance change to instrument and causes imbalance in bridge circuit. Movement of slidewire in rebalancing circuit is measure of change in concentration

ing several and a correction in a measurement can be made for the other chemicals present, such as by a specific gravity measurement.

▶ Considerations for Applications

Compensation for temperature of the solution is necessary since conductivity increases approximately one per cent for each rise of one degree Fahrenheit. In practice this compensation can be taken care of by proper setting of the conductivity instrument but the solution must be specified o obtain highest accuracy as the temperature coe ficients for acids, alkalis and salts are slight different.

However, conductivity control can be applie within the limitations indicated. The concentr tion change involved in a process being controlle must be greater than the sensitivity range of th instrument; in general, control is best applied t dilute solutions, since relatively small addition of chemicals result in relatively large changes i conductivity. In the dilute range, conductivity i proportional to the chemical concentration so tha straight line calibration is possible for a limite range. It is only for a change of 500 per cent in concentration that there is any appreciable deviation from linearity for dilute solutions. For a dilute solution, such as raw water, conductivity offers an accurate control method and for a very dilute solution, such as distilled water, this method is among the most accurate known.

For solution concentrations up to 5 per cent the conductivity method readily applies and linearity for the control range is good. Solutions of greater than 5 per cent concentration are being controlled, but there are losses both in linearity and accuracy at higher concentrations. Fortunately, processing solutions, such as cleaning solutions and brines, only require a control range of 10 to 20 per cent of the total concentration and are generally in a controllable range by conductivity methods; the accuracy of measurement and control are about 5 per cent or one-fourth to one-half of the usual control range.

The equations and calibations necessary to define a chemical concentration range are relatively simple. Equations that are convenient, but not necessary, to define a range with a minimum of calibrations are given in TABLE 1. Direct calibration of an instrument is common and in many cases no calibration is required. A fixed resistance can be used as a standard if it is desirable to check a calibrated instrument. In many cases industrial conductivity instruments are calibrated in terms

TABLE 1

Basic Conductivity Equations

Conductivity $c = \dfrac{1}{r}$

Resistivity $r = \dfrac{Ra}{l}$

Cell Constant $c = kC$

Conductivity Proportional to Concentration $RC_o = K$

Temperature Coefficient $R_m = R_t\,[1 + x\,(t - m)]$

C = conductance (mhos)
k = cell constant
C_o = concentration (grams/liter)
K = constant
R_m = resistance at temp m
R_t = resistance at temp t
x = temperature coefficient

c = conductivity (mhos/cm)
r = resistivity (ohm cm)
R = resistance (ohm)
l = length of conductor or confined length (cm)
a = cross sectional area or area of electrodes if cross section is confined (sq cm)

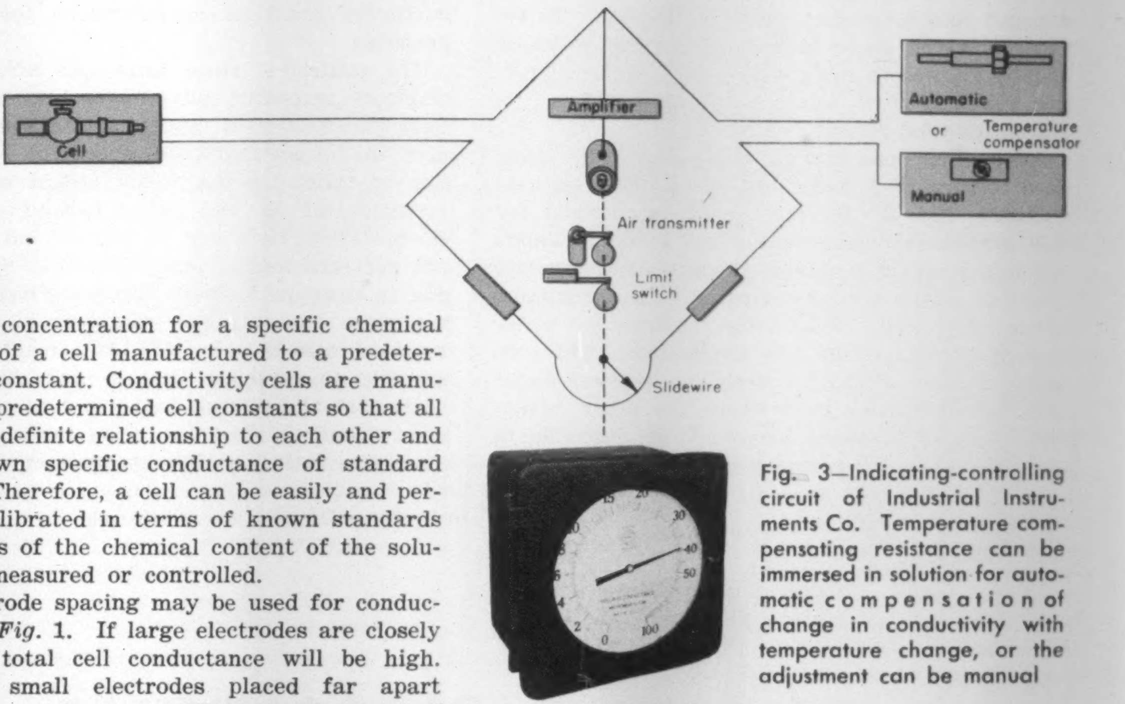


Fig. 3—Indicating-controlling circuit of Industrial Instruments Co. Temperature compensating resistance can be immersed in solution for automatic compensation of change in conductivity with temperature change, or the adjustment can be manual

of solution concentration for a specific chemical by the use of a cell manufactured to a predetermined cell constant. Conductivity cells are manufactured to predetermined cell constants so that all cells bear a definite relationship to each other and to the known specific conductance of standard solutions. Therefore, a cell can be easily and permanently calibrated in terms of known standards and in terms of the chemical content of the solution to be measured or controlled.

Any electrode spacing may be used for conductivity cells, *Fig.* 1. If large electrodes are closely spaced the total cell conductance will be high. Conversely, small electrodes placed far apart result in low conductance. Thus a wide range of solution conductivities can be measured, within the limitations of a measuring instrument, by selection of the proper cells.

▸ Balancing Circuit Used

A typical measuring circuit involving a conductivity cell is shown in *Fig.* 2. In operation a change in conductivity of the cell results in a change of resistance *b-c* and an imbalance of the bridge. Imbalance produces a voltage across *a-c* which is amplified to drive the balance motor and reposition a slidewire in a direction to reduce the voltage and eventually restore balance. By the use of an indicating needle and a pen co-ordinated with the slidewire, the instrument is used as an indicating recorder.

The arm of the circuit *d-c* may be provided with a variable resistance for manual compensation for temperature corrections or it may be provided with a compensating resistance when the instrument is used for a solution of known coefficient of temperature change. The compensating resistance can be immersed in the liquid that is being controlled in order to respond to the same temperature changes effecting the conductivity cell. A number of switches and an air transmitter can be activated by cams on the balancing shaft to affect control over a process at a number of conductivity measurements or to effect *On-Off* control over a conductivity range.

A low cost electronic industrial controller is available that consists of a line-operated ac Wheatstone bridge using an electron ray tube as the null indicator. It also contains a vacuum-tube relay which operates directly on the bridge imbalance. When the conductivity of the solution deviates from the manual setting, the relay can be made to operate warning signals or control solenoid valves. This type of instrument can be used to measure, signal and stop the flow of distilled water for an electrolyte concentration increase of as little as 0.10 ppm, *Fig.* 3.

Basic instruments are available for single-point or multiple-point recording or controlling so that instrumentation is practical where conductivity can be used as a control factor. These instruments are for analytical purposes, indicators, controllers, warning devices and automatic guards against contamination. For instance, automatic instruments are commonly used to control boilers, stills and demineralizers. Also they are used to guard steam coils and water coils used for heating or cooling of chemical solutions. An instrument will detect a leak, sound a warning and interrupt the flow to safeguard equipment and avoid discharge of valuable or contaminating chemicals to a sewer.

▸ A Specific Application

An interesting recent development in the electroplating field and an excellent example of the use of conductivity control is the adaptation of conductivity meters to automatic rinse tank control. Shown in *Fig.* 4 are components used for rinse tank control. Rinse waters are continuously contaminated from drag-in of solution from the preceding tank by the work in process. If chemicals are allowed to build up in the rinse, the work will be spotty on drying. Also the chemicals will be dragged into succeeding tanks in the line. To reduce or avoid these troubles the rinse water is usually allowed to run continuously. Such a practice requires more water than the minimum required for good rinsing.

Automatic conductivity controllers are being used to turn rinse waters on and off at a set conductance, *Fig.* 5. By the use of a controller for this purpose the rinse water can be continuously controlled within a narrow chemical concentration range to assure adequate rinsing with a minimum usage of water. Substantial savings in water have been realized by this application. The controller will easily pay for itself due to lower water costs and in many cases there are other advantages. It is at times necessary or desirable to treat the rinse for recovery of metal values or to destroy toxic chemicals. The controlled rinse allows for collection of these rinse waters at the maximum practical concentration for treatment purposes.

The controlled rinse tank also affords an example of secondary advantages that often accrue from the controlled process. If a water meter is used in conjunction with a controller, then data can be taken on the total amount of chemicals accumulating in and being carried off by this rinse. These data can be used to calculate drag-out per rack and to study means to reduce losses due to drag-out. From the same basic data and the rinse concentration the drag-in to the next tank can also be estimated. As a result it becomes possible to correlate drag-in and drag-out with control of the plating baths and to arrive at the most economic flow for rinse tanks in order to maintain plating quality at minimum water costs.

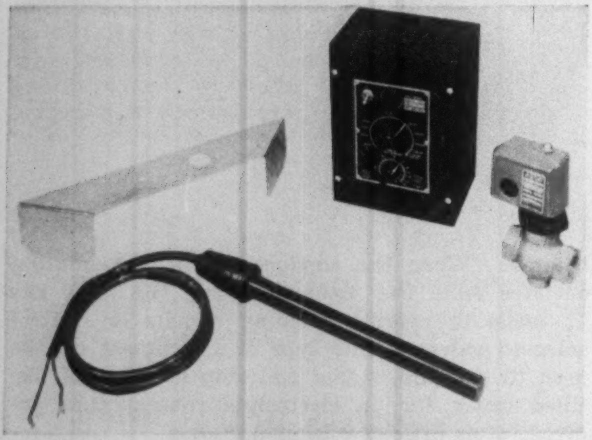


Fig. 4—Electronic controller, electric valve, dip cell and bracket used for control of rinse tank on automatic barrel plating machine. Use of this equipment provides for adequate rinsing with minimum usage of water

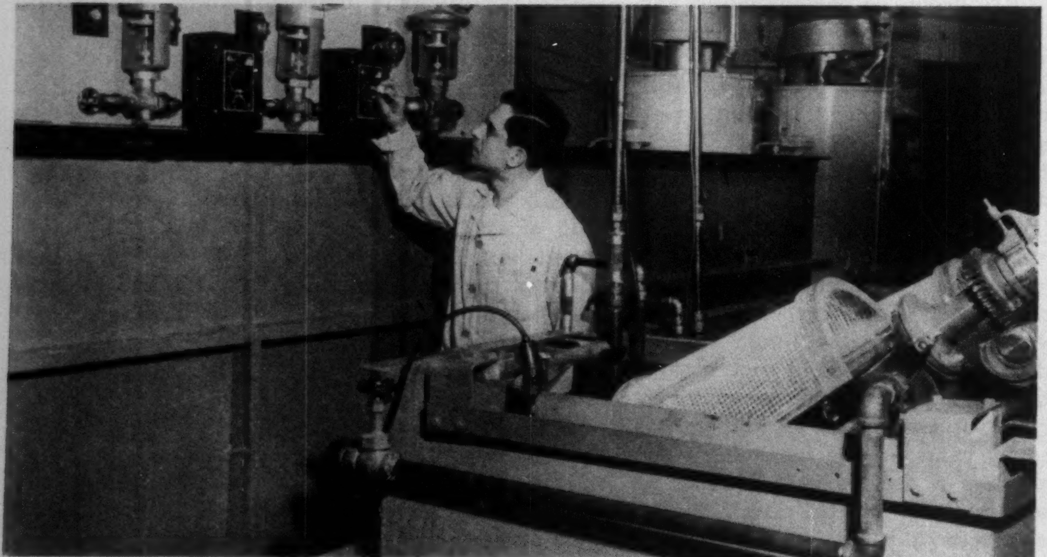
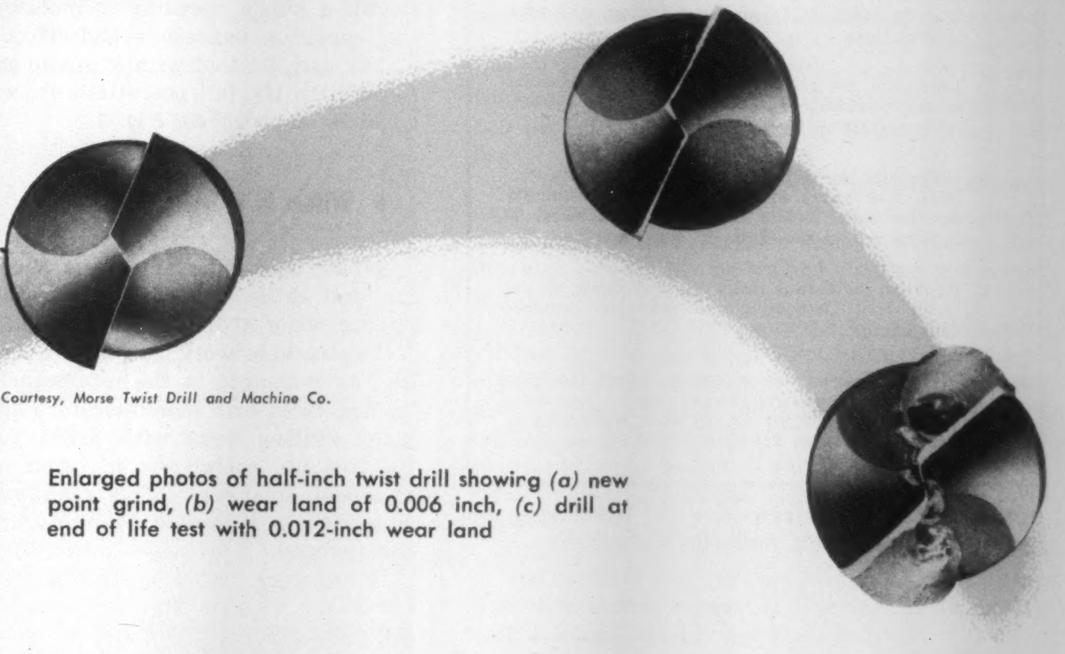


Fig. 5—Operator setting automatic rinse tank controller of automatic barrel plating machine. Deviation of solution from desired conditions causes motor controlling solenoid valve to turn rinse water on and off, insuring maximum rinse usage of a given quantity of water

By GEORGE H. AMBER
Consulting Engineer
Detroit, Mich.



Courtesy, Morse Twist Drill and Machine Co.

Enlarged photos of half-inch twist drill showing *(a)* new point grind, *(b)* wear land of 0.006 inch, *(c)* drill at end of life test with 0.012-inch wear land

AUTOMATIC DULL DRILL DETECTION

Downtime is a big factor in the success of an automated installation. The problems of minimizing shutdowns to change worn tools and of discovering impending dullness before it produces serious production difficulties are a major concern of the machine tool designer and the production man

SPOTTING DULL TOOLS before they fail has presented a continuing problem for machine tool designers and the automation industry. Methods and techniques of solving this problem are presented in this article. Knowing the characteristics of any drill, under the contemplated working conditions of load, rate, speed and material, it is entirely possible, by means of statistical analysis, to predict the number of such drills that will have failed after any given time. But the fact remains, no one can predict just when any one tool will fail.

This paper will show what the time-tested methods are of detecting dull drills, and what modern automatic methods can accomplish the same end. Drills were chosen for this discussion as considerable investigation has been made on drilling. Furthermore, the ubiquitous machine tool drill is frequently encountered in automation.

The practice of group changing of all tools in a machine or line according to a strict schedule certainly helps reduce machine downtime caused by abrupt and unexpected tool failures. However, the most frequent tool replacement

1. Determine the cost of replacing a single drill. Include labor, tool cost per grinding, and production loss.
2. Determine the cost of replacing all of the drills in the machine. Also include labor, tool cost, and production loss.
3. Calculate, or determine from production-records, how many individual drill replacements can be made before it is more economical to replace all of the drills in the machine.
4. Replace individual drills, on the basis of the "Drill Tool Detector" until the next general drill change.
5. When all drills are replaced, select the best ones (those showing least wear, by wear land inspection) for use as spot replacements prior to the next scheduled drill replacement.

Fig. 1—Recommended procedure for establishing drill replacement policy for multispindle machines

schedule does not entirely eliminate tool failures.

Every time a serviceable tool is needlessly replaced there are two direct economic losses. These are the direct dollar loss of the tool itself and tool setter's time; and the production loss of not only the disabled unit, but of the many other stations affected. Yet, unless drills are changed according to a schedule that removes a good number of serviceable ones, an excessive number of machine stoppages due to failures will result. It certainly is not necessary to cite here the ill effects of continuing production with a dull drill.

It has been indicated at industry conferences and by technical papers that an indicator is desirable to show when tool failure is imminent. This indicator would also be useful for reversing the feed in the drilling operation. A "tool condition indicator" would allow a considerably longer ti e to elapse between group replacements. It wou d permit a single operator to monitor a number f tool condition indicators, and effect a replaceme t of any specific tool with a minimum of downtim . In addition the full potential serviceability of too s could be approached, *Fig.* 1.

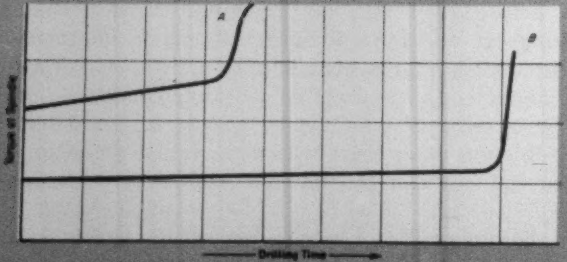


Fig. 2—Curves represent typical plot of torque requirement versus drilling time—A for drilling in cast iron, and B drilling in mild steel. Tests involve constant feed per revolution. The amount of material removed is proportional to drilling time

▶ When Is a Drill Dull?

Before discussing automatic methods of detecting dull drills, the standard methods for determining when a drill is dull should be considered.

Considerable work has been done on twist drill life, as evidenced in the references[1]. Some of the leading twist drill manufacturers have run a great many cutting tests with drills, for ascertaining the tool life correlation in terms of design, steel and heat treatment. This requires determination of when a drill is dull, to a constant, reproducible end point.

It has been found by the Morse Twist Drill & Machine Co. that the reproducible endpoint of drill life can be considered to be when: (1) The drill squeals, (2) there is an increase in operating thrust, (3) a given wear land develops (example, 0.012 inch for a ½-inch drill).

Various investigators (listed in the references) have used like criteria in determining when a drill is dull. Varley[1] considered a drill dull when the first squeal was heard.

Benedict and Lukins[4] evaluated cutting lift from either the torque, thrust, or power readings, or a combination of them. For example, the drill was assumed dull when the drive motor power requirement increased by 30 per cent; or dynamometers were used to measure torque and thrust, which were found to increase rapidly due to drill wear. A thrust indication, by itself, was also found to be a yardstick of drill condition.

The Research Department of the Institution of Production Engineers in England uses a sudden increase in torque to determine when a steel cutting drill is dull. However, the Institution points out that the characteristics of the torque curve vary greatly, depending upon whether normal or severe cutting conditions prevail.

In drilling cast iron a continuous increase in torque requirement develops. Consequently, rather than use the sudden increase of torque representative of drilling steel, a different criteria is used as the index of dullness, namely, a 20 per cent increase in torque. Thrust and torque versus drill life for short, medium and long life tests in steel and short and medium life tests in cast iron have been observed and the relationships are plotted in the form of curves[2].

The basic factors of twist drill life have changed little over the years. This is confirmed by a United States Air Force Report of 1950. This report[3] contains a plot of drill life versus torque. It shows that there is definite correlation of the

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[1] References are tabulated at end of article.

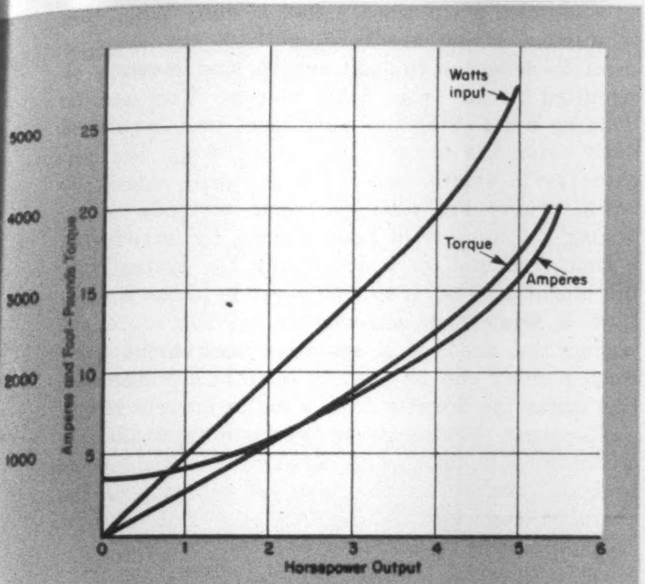


Fig. 3—Performance curves of a typical three horsepower induction motor. Watts input, torque, and amperes are all proportional within the two to four horsepower working range. Therefore either watts input or amperes can be used as an index of developed torque

two variables, provided constant speed exists, but there is no correlation except under the constant speed condition. A second plot shows that there is also a correlation between drill life and power consumed in drilling. This work was done with Timken Alloy 16-25-6.

These all add up to the following indications of drill dullness:

(1) The drill squeals, (2) in constant feed arrangement there is an increase in thrust, (3) a wear land of minimum size develops, (4) drive power requirement (watts input) increases up to 30 per cent over normal, (5) sudden increase in torque and thrust when drilling steel, (6) a continuous increase in torque and thrust, exceeding 120 per cent of normal torque, when drilling cast iron.

As long as a skilled, or even semi-skilled operator handles a drilling machine, the squeal or wear land methods can be used. Of course, the operator usually has no way of knowing the torque or horsepower required.

Replacement of the operator, by the automatic cycling type of machine, is not all blessing. Lacking the operator's senses (including common sense), the machine indiscriminately uses drills regardless of condition. It would be desirable to instrument the machine so that it could detect some variable that has a correlation with drill dullness.

Neither the squeal nor wear land are amenable to instrumentation, by an electrical transducer. However, thrust torque and power input can be readily measured by electrical methods.

Detection by Torque Measurements

Shown in *Fig.* 2 are idealized curves showing the torque requirement, plotted against drilling time, of a typical drill being used in cast iron and in mild steel. Feed and rpm are held constant. Note that the torque requirement increases gradually, with time of use. Shortly before complete failure of the drill the slope of the curve increases rapidly. This is to be expected, for the beginning of cutting edge breakdown is accompanied by heat, which further accelerates breakdown. In both cases the torque requirement can be used as an indication of drill condition.

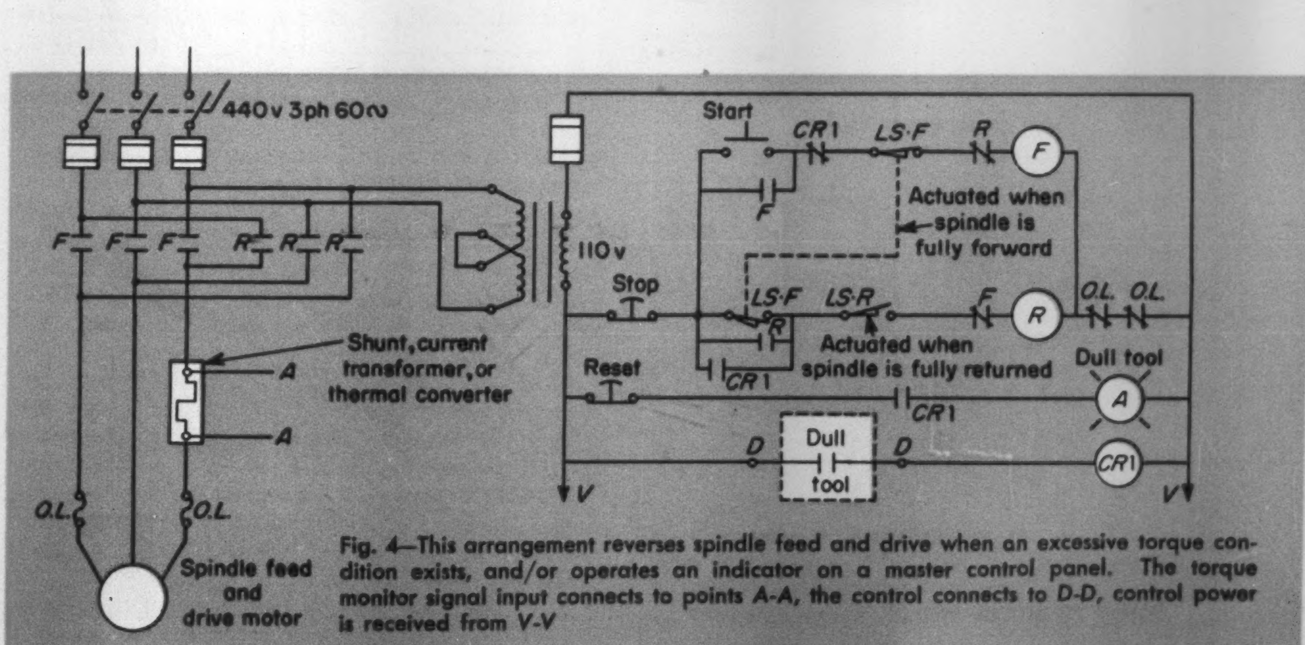

440v 3ph 60∿
F
F
F
R
R
R
110v
Shunt, current transformer, or thermal converter
A
A
O.L.
O.L.
Spindle feed and drive motor
Start
CR1
LS·F
R
F
Actuated when spindle is fully forward
Stop
LS·F
LS·R
F
R
R
CR1
Actuated when spindle is fully returned
O.L.
O.L.
Reset
CR1
Dull tool
A
D
Dull tool
D
CR1
V
V

Fig. 4—This arrangement reverses spindle feed and drive when an excessive torque condition exists, and/or operates an indicator on a master control panel. The torque monitor signal input connects to points A-A, the control connects to D-D, control power is received from V-V

Single Spindle Machines

On a single spindle machine the practical application of this relationship is not a difficult problem. As most drills are driven by electric motors, and motor current or input power is a function of the torque being developed, a current or power sensitive device can be used to indicate torque. *Fig.* 3 shows the current, torque and watts versus horsepower curves of a typical machine tool induction motor. An ammeter, or equivalent, in the line indicates the torque requirement of the drill, as also does a wattmeter. In most modern drilling machines, most of the torque requirement can be considered as being used for the drilling operation. The torque required to develop the thrust and machine losses can be neglected.

There are several commercial methods of instrumenting a motor line with a torque indicator, *Fig.* 4. *Figs.* 5 and 6 show use of a sensitive meter type relay. It can be used to sound an alarm or otherwise warn when a tool is dull. While this is a most straightforward method, the arrangement is sensitive to load surges, and must be so circuited as to avoid false alarms. This can be done by not cutting the instrument into the circuit until after the surges that occur when the machine cycle starts, and when the drill enters the work. There are also electronic methods of reducing the number of false alarms, by introducing a time constant; or desensitizing the system during motor surges. It is also possible to use a relay that is somewhat self-amplifying, *Fig.* 5, eliminating the need of a sensitive instrument type. Such a relay can be used to operate a motor control contactor directly from a motor current shunt.

The main advantage of determining torque requirements by means of drive motor analysis, is that all instrumentation can be external of the machine, and that the machine need not be especially designed to accommodate this method.

Multispindle Machines

The torque detection methods discussed, while largely suitable for single spindle machines, are less suited for multispindle applications. Yet, the

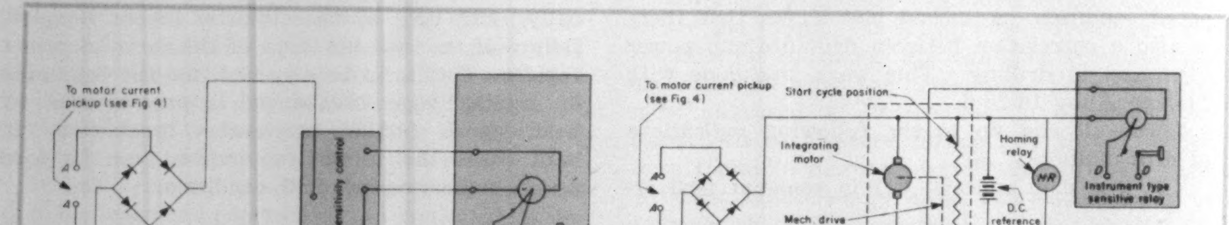

To motor current pickup (see Fig 4)
A
A
Sensitivity control
D
D
Instrument type sensitive relay
110 v ac
V
V
Sensitivity control
Pri.
Transformer relay (induction relay)
L.V. sec.
A
A
Current transformer
D
D
To motor current pickup (see Fig 4)
Start cycle position
Integrating motor
Mech. drive
HR
HR
Homing relay
HR
D.C. reference voltage
Homing switch
D
D
Instrument type sensitive relay
Integration cycle timing control
To motor current pickup (see Fig. 4)
Wattmeter type integrator
HR
A
A
HR
HR
HR
Current coil
Wattmeter armature
Voltage coil
Mech. drive to cam switch
D
Dull tool contacts (see Fig. 4)
D
Step-down transformer for reversing power
V
To control voltage (proportional to line voltage)
V
Mech. drive to cam switch
Homing relay
HR
Homing switch
Integration cycle timing control

Fig. 5—Use of various types of equipment as torque monitor (a) instrument type sensitive relay (b) self amplifying transformer relay contactor (c) current integrating unit (d) power integrator

problem as it exists in industry, for example modern automation transfer machines, is for the most part a multispindle problem.

Suppose we attempt to detect torque increases by simply setting on overcurrent relay into the multispindle drive motor circuit. This procedure will most likely fail regardless of how sensitive a relay is used. Not only would normal motor current fluctuations tend to mask any increased torque requirements, but the various drills driven by the motor may be wearing unequally. That is, the additional torque required to drive a dull drill is obscured by the torque required to drive the parallel drills that are not dull. This factor, plus the normal line voltage fluctuation common in any industrial plant, makes it difficult to detect the increase.

Courtesy, J.I.C. Electric Co.

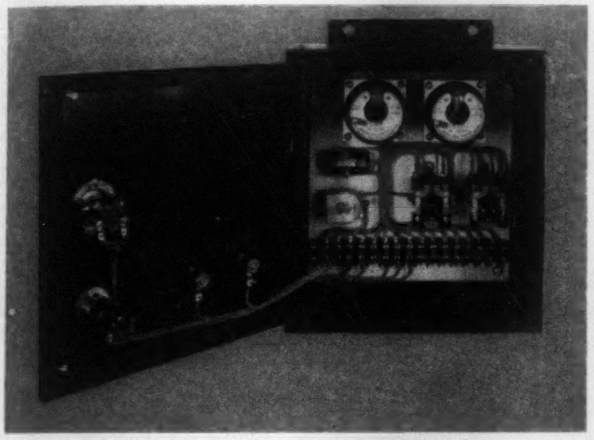


Fig. 6—Load switch using instrument type sensitive relays

What we are actually after is the increase (the amount exceeding the requirement of sharp drills) in torque demanded by the dull tool. While it was shown that instantaneous drive motor current is an unreliable indication of a dull tool in a multispindle arrangement, let us consider the value of a time integration of motor current. The integration of motor current for a definite interval of time is the equivalent of the average current for that interval of time. Suppose we plot drive motor current, while drilling with sharp tools. Then, we superimpose a plot of drive motor current while drilling with a dull tool present, among the sharp ones. The area between curves would represent the time integration of the torque resulting from the increased demands of the dull drill. This area is proportional to both the duration of the integrating time, and the net increase in motor current. The greater the area, the more positive an index of tool dullness we have.

Therefore, there are two main rules to go by in discriminating between a sharp tool torque-time integration and a dull tool torque-time integration for the purpose of indicating tool condition: (1) The fewer the number of drills, the greater the incremental increase due to a single dull drill; (2) the longer the integrating time (a number of drilling cycles, if need be) the greater the torque-time integration.

Integration of this type can be readily accomplished by the use of either a servo-integrator, or integrating motors or instruments, *Fig.* 5. The servo-integrators are usually most flexible and sensitive. However, they ordinarily rely upon electronic amplifiers while the directly operating integrating motors and instruments do not. In any case, these are all electromechanical integrators. At any instant, the angular velocity or rpm of a "rate-servo" or integrator is proportional to the motor current. Consequently, the number of degrees an integrating servo or motor shaft rotates is proportional to the time integral of the instantaneous rpm values.

The integration shaft is mechanically connected to a switch, via a reduction gear box. The principle of setting up the arrangement is as follows: Assuming the integrator is operating, and sharp drills are being used, the angular rotation and terminal position of the shaft are recorded. This represents the current versus time integration, using sharp drills.

Alarm switch contacts are indexed to a predetermined number of degrees beyond the sharp drill integration position. This advance represents the maximum allowable increase in current versus time integration permitted. It is based on either experimental methods, or on analysis of motor current curves, representing various tool conditions.

Considerable switching and sequencing circuitry is required to implement this type of instrumenta-

Courtesy, Scully-Jones & Co.

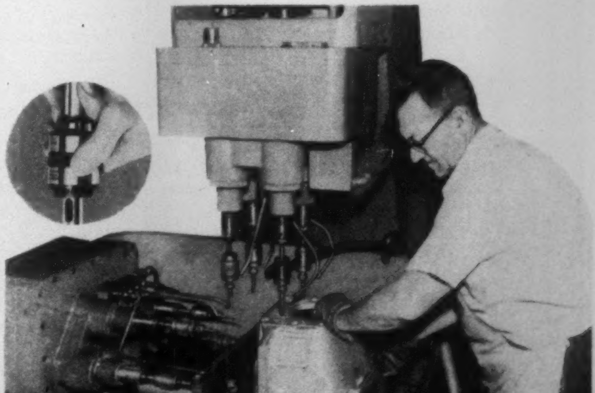


Fig. 7—Multispindle drilling machine equipped with adjustable torque releasing clutches. Inset shows close-up of adjustment of clutch

tion. Also, integrator time constant effects must be considered. For example, the integrator must be allowed to function only during active drilling time. If several drilling cycles must be used for a satisfactory integration level, the sequencing and switching must "home" the integrator after the programmed number of drilling cycles.

Watt input can be integrated, rather than motor current, with similar results. An interesting variation is the integration of power-squared or motor current-squared, by a thermal converter transducer. This has the advantage of rendering the control system more sensitive.

The electromechanical type of integration is not the only way of accomplishing the purpose; for thermal, or straight electronic techniques may be equally suitable.

The major advantage of this torque integration high-limit technique is that it may be applicable for existing machines, without requiring any internal instrumentation or modifications. Though integration methods are a powerful technique, borrowed from the servomechanism engineers' bag of tricks, they are not a panacea to solve any or all multispindle dull tool problems. This technique is most likely to succeed if the machine is designed so that it is compatible with both the limitations and advantages of using integrators.

While this paper primarily concerns dull tool detection by electrical methods, the use of a straight mechanical torque limiting clutch should be considered. These can often be used on exist-

TABLE 1

Data Chart for Torque Methods of Dull Drill Detection

Device	General Description	Single Spindle Machines	Multispindle	Sources and References
Instrument type relays	A practical and simple method for single spindle machines operating at constant feed and rpm. Easily adjusted.	Successful if the drill is not overpowered. No machine modifications are required. Can be fully automatic, reversing feed when torque is excessive. Somewhat susceptible to false alarms due to line surges and "noise" but can be compensated by electronic circuits.	Seldom suitable, as the increased current demands of a dull drill are obscured by current demands of normal drills.	*Basic Instruments:* Weston Electrical Instrument Corp. Assembly Products, Inc. *Complete Monitors:* J.I.C. Electric Co. Kirkman Torque Control Co. Detroit Milling Cutter Co. Electronic Control Corp.
Magnetic relays	Self amplifying requires no electronics.	Same data as instrument type listing above.	Same data as instrument type listing above.	Birmingham Controller Co. General Electric Co.
Torque cutouts (clutches)	Suitable in many cases. Less readily adjusted than current detectors.	Satisfactory method in numerous installations.	One required for each spindle. Machine design considerations involve additional mounting room.	Anchor Steel & Conveyor Co. Scully-Jones & Co.
Torque meters (strain gages)	Highly suitable for experimental investigations.	Not especially suitable for industrial installations.	Not especially suitable for industrial installatiaons.	Baldwin-Lima-Hamilton Corp.
Current integrators	Ordinary amplifiers are not required as direct electro-mechanical integrating instruments are available. Elaborate timing and sequencing circuitry is usually necessary. Requires no mechanical modifications.	Takes over where current sensitive relay leaves off. Especially valuable for low torque increase conditions. Somewhat more expensive than instantaneous current monitoring.	A most promising method. Effectiveness is directly proportional to the number of spindles. In some cases integration of the square of the motor current (from a thermal converter) aids in defining a torque increase. Conventional servo integrators can also be used.	*Integrating Instruments:* Cedar Engineering Co. Summers Gyroscope Co. General Electric Co. Weston Electrical Instrument Corp. *Servo Integrators:* Servo Mechanisms Inc. Link Aviation Inc.

ing machines. However, they ordinarily do not warn of an impending tool failure. *Fig.* 7 shows adjustable torque releasing clutches used in a multispindle machine. As such clutches can ordinarily be set only to certain fixed values, the rate of feed must be adjusted to produce the proper torque reaction necessary to activate the clutch.

TABLE 1 summarizes torque methods.

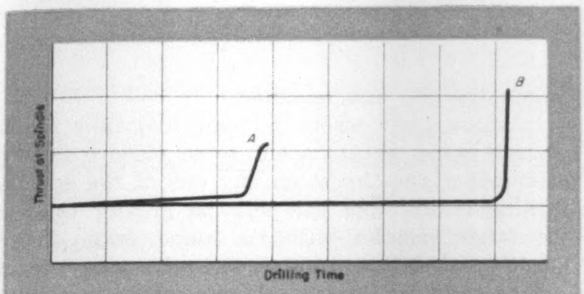


Fig. 8—Curves represent typical plot of thrust at spindle versus drilling time—A for drilling in cast iron and B drilling in mild steel. Tests involve constant feed per revolution. The amount of material removed is proportional to drilling time

▶ Detection By Thrust Measurements

Shown in *Fig.* 8 are the thrust requirements of drills being used in cast iron and steel respectively, plotted versus drilling time. These curves too are idealized ones, representing typical conditions encountered when drilling cast iron and steel. Tables listing the recommended rate of feed and rpm for various materials, are in the popular handbooks. For any rpm and rate of feed parameters selected for a job, there is also an associated thrust condition listed. This represents the conditions when using a sharp drill. The amount of thrust increase to be expected from a dull drill, and the pattern of this increase, was first determined by experimentation years ago.

The pre-World War I experimenters placed an oil-filled metal bellows at the top of the drill spindle. A hydraulic line from the metal bellows was run to a steam engine indicator card arrangement, which recorded directly the pressures resulting from the drilling operation. This pressure was converted to thrust.

Nowadays there are a number of methods of translating force (thrust) into electrical signals, in addition to the hydraulic bellows method, *Fig.* 9.

There are mechanical design problems affecting the thrust measurement method of dull tool detection. Prior to the introduction of hydraulics to machine tools, large drilling machines almost universally used positive feed arrangements, being driven by suitable back gears and lead screws. In such cases, spindle thrust could be used as an index of tool condition. With the advent of hydraulic feeds, this is a less opportune method. This is because piston hydraulic feed is usually a "constant pressure" system, meaning that thrust does not increase appreciably, but the feed rate of drilling decreases.

In addition, even drilling machines with mechanical feed must usually be specially designed to accommodate the transducers and lines. Also, most of the signals are of a low level and require an amplifier. Fortunately, such amplifiers and transducers are commercially available and have proved to be as reliable as any machinery with which they are likely to be associated.

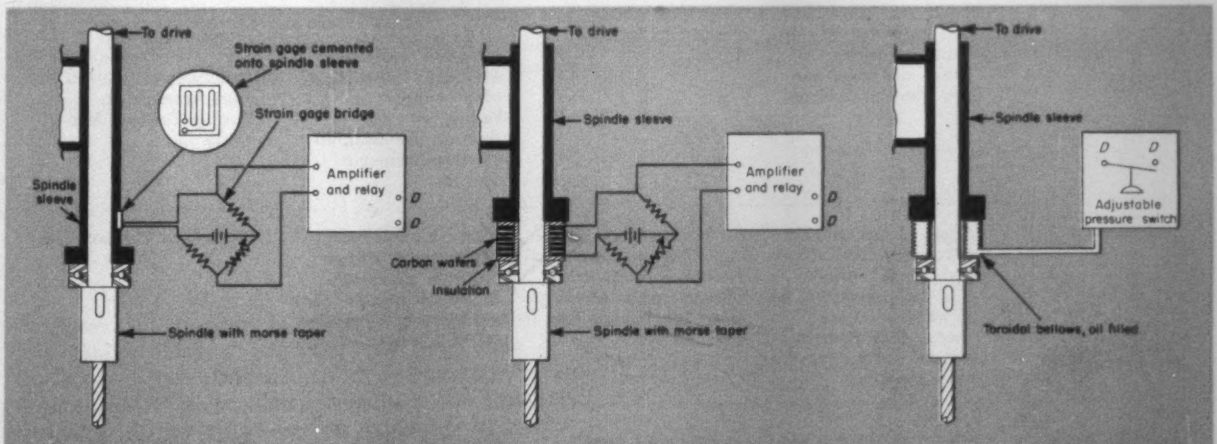


Fig. 9—Use of various types of equipment as thrust monitor (a) strain gage and amplifier (b) carbon compression wafers (c) oil filled bellows and pressure switch

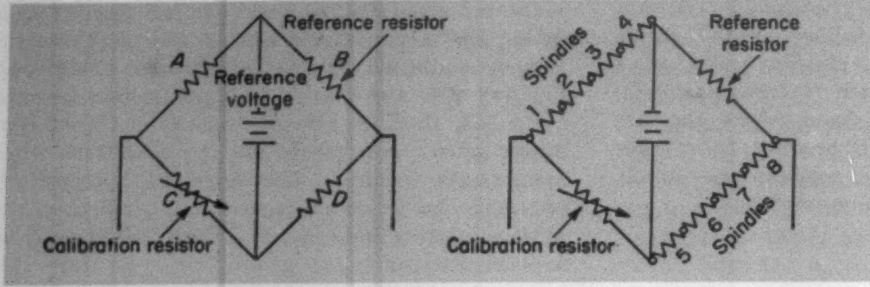


Fig. 10—Basic bridge circuit *(a)* and multiple bridge circuit *(b)* for either strain gages or carbon piles

▶ Multispindle Instrumentation

There are several aspects to the thrust measurement method of dull tool detection, considering multiple spindle machines. It will soon be shown that each case is unique, and that the machine must be designed for compatibility with the instrumentation, as well as having the instrumentation match the job and machine.

In those cases where a single hydraulic piston, or lead screw arrangement force feeds a number of spindles, the thrust on any one of the spindles turning a dull tool will still be greater than on the other spindles with the same duty. Consequently, an electrical balanced bridge arrangement can be used for instrumentation. Due to the use

TABLE 2

Data Chart for Thrust Methods of Dull Drill Detection

Device	General Description	Single Spindle Machines	Multispindle Machines	Sources and References
Hydraulic bellows	A rugged device, can be entirely nonelectric. These oil filled cells can transmit pressure to an external pressure switch or indicator (steam indicator or calibrated Bourdon gage).	Requires special machine design. Can be adapted to some sensitive machines without difficulty. A good method for those who are "electronics shy."	Suitable. One required at each spindle. Special adaptation of the spindle head unit necessary.	Fulton Sylphon Div. of Robertshaw Fulton Controls Co. Flexonics Corp. Diaflex Div., Cook Electric Co.
Strain gages	Require an adapter to convert thrust into strain. Amplifiers and considerable circuitry necessary. These are very rugged simple devices.	Especially suitable for experimental purposes where it is desired to record thrust.	Strain gage and adapter are comparatively small, this is desirable in crowded multispindle head units. Can also be used in bridge circuits, reducing the number of amplifiers required.	*Strain gages:* Baldwin-Lima-Hamilton Corp. Trans-Sonic Inc. *Amplifiers:* Ellis Associates Young Testing Machine Co.
Carbon piles	Adapter not usually necessary. Not rugged. High output. Amplifier may not be necessary in most cases. This device is inherently pressure sensitive.	An inexpensive method. Can operate conventional indicators. Considerable development work may be necessary.	Can be used individually or in bridge circuits. Promises to be an inexpensive solution but requires careful development.	Stackpole Carbon Co.
Piezoelectric crystals	Small, sensitive and inexpensive. Require an amplifier, and shielded wiring. Affected by temperature and humidity.	Suitable for sensitive machines rather than heavy machinery.	Requires little mounting room or deflection.	Brush Electronics Co. Stupakoff Ceramic & Mfg. Co.

Fig. 11—Block diagram of a dull tool detection system for multispindle machine tools. Blocks represent functions, not physical entities; in practice considerable simplification and consolidation of functions are possible.

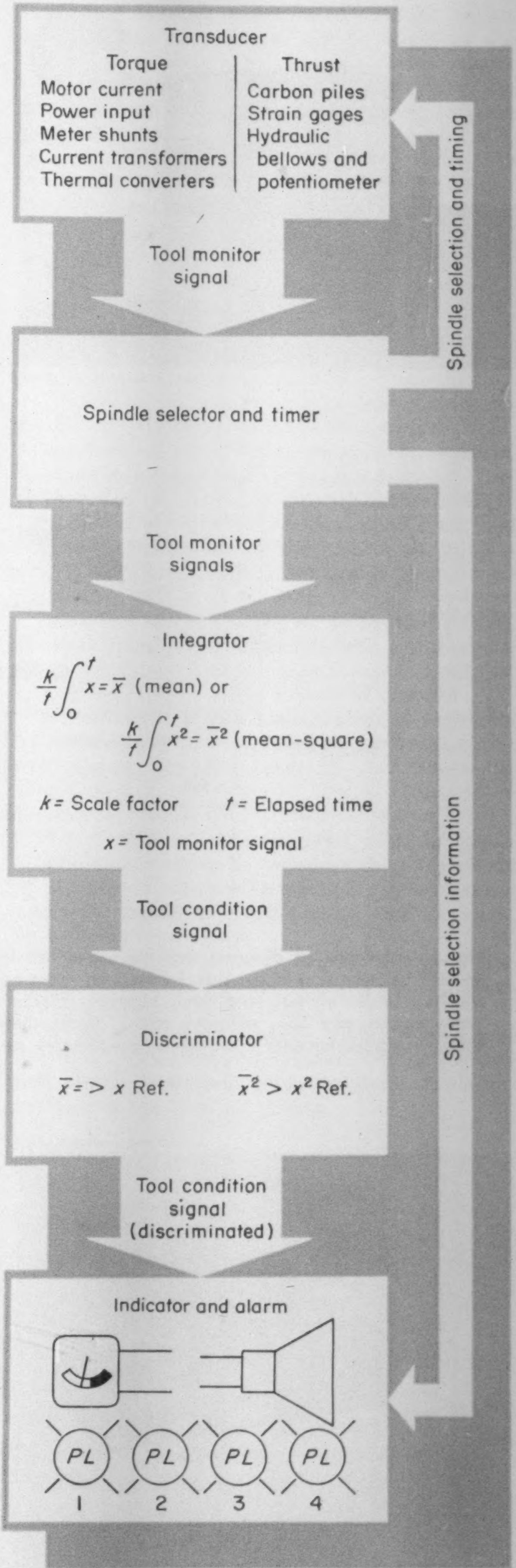
The "pickup" element indicates conditions at the tool. Either thrust or torque are monitored as indications of tool condition. Preferably, each spindle is monitored by separate pickup. Being a function of torque, motor current can be used to indicate torque. Therefore watts input also indicates torque as voltage is substantially constant.

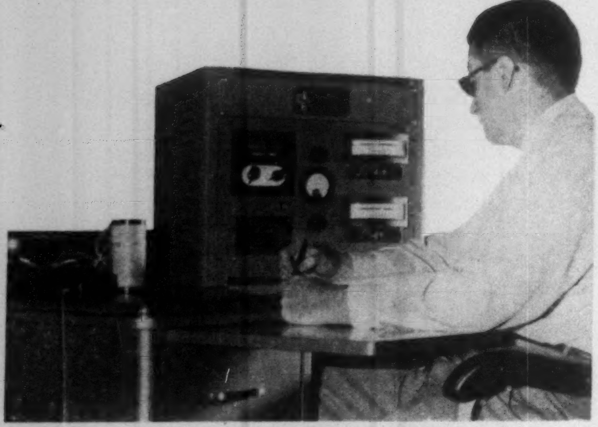
Sequences integrator input to spindle pickups, according to tool monitor program. Concurrently selects proper spindle pilot light and indicator instrument. Starts integration function at predetermined point of machining cycle, and stops integration after fixed elapsed time. "Homes" integrator preparing it for next operation. This is done by temporarily converting integrator from rate servo to positional servo where a servo-type integrator is used.

Avoids false dull tool alarms due to instantaneous load peaks and makes the control effectively more sensitive. Continually sums the instantaneous levels of thrust or torque for a precise time interval. This is equivalent to the average, (arithmetical mean.) For a more sensitive indication, the mean-square may be used as the criteria of tool condition, instead of using the mean for this purpose. Develops tool condition signal from instantaneous tool monitor signals.

Compares the mean (X) or the mean-square (X^2) of the tool monitor signal (from the integrator) to a reference which is equivalent to the like signal of a serviceable tool. Under favorable design conditions the mean-square method may be able to detect one dull drill among multiple spindles by instrumenting the current of the drive motor.

Activates tool condition indicator at control panel when tool condition signal (computed by integration of instantaneous tool monitor signals) exceeds preset reference signal. Or, continually measures the tool condition signal by means of a meter marked with "working" and "dull" ranges; may also sound an alarm when tool failure is imminent.


Transducer
Torque
Motor current
Power input
Meter shunts
Current transformers
Thermal converters
Thrust
Carbon piles
Strain gages
Hydraulic
bellows and
potentiometer
Spindle selection and timing
Tool monitor signal
Spindle selector and timer
Tool monitor signals
Integrator
$\frac{k}{t}\int_0^t x = \bar{x}$ (mean) or
$\frac{k}{t}\int_0^t x^2 = \bar{x}^2$ (mean-square)
k = Scale factor
t = Elapsed time
x = Tool monitor signal
Tool condition signal
Discriminator
$\bar{x} = > x$ Ref.
$\bar{x}^2 > x^2$ Ref.
Tool condition signal (discriminated)
Spindle selection information
Indicator and alarm
PL 1
PL 2
PL 3
PL 4



Courtesy, Cedar Engineering Co.

Fig. 12—The Cedar integrator can be used to detec dull tools in multispindle machines. The computer con sists of two sections. One section can be used to moni tor the integration of the square (mean square) of the drive motor current or thrust signal. The other section can be used to monitor the integral (mean or arithmetical average) of the drive motor current or thrust signal. Ordinarily only one method is used. The mean square method is more sensitive but may be more readily disturbed by "line noise"

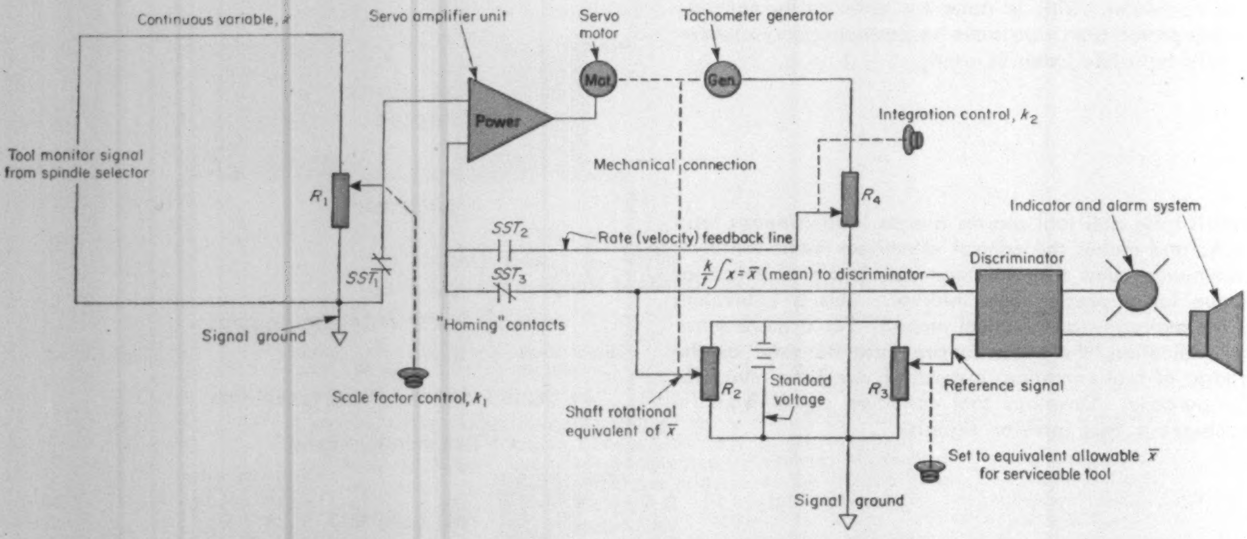

Continuous variable, x
Servo amplifier unit
Servo motor
Tachometer generator
Mot.
Gen.
Power
Integration control, k_2
Tool monitor signal from spindle selector
Mechanical connection
R_1
R_4
Indicator and alarm system
SST_2
Rate (velocity) feedback line
SST_1
SST_3
$\frac{k}{T}\int x = \bar{x}$ (mean) to discriminator
Discriminator
"Homing" contacts
Signal ground
Standard voltage
R_2
R_3
Reference signal
Scale factor control, k_1
Shaft rotational equivalent of $\bar{x}$
Set to equivalent allowable $\bar{x}$ for serviceable tool
Signal ground

Fig. 13—Operational diagram showing use of an integrator to compute X, mean of drive motor current or spindle transducer (pickup) signal based on servo type analog computer techniques. The discriminator is also shown. Under normal conditions, between spindle checks, the contacts are as shown. SST_1 and SST_3 normally closed, and SST_2 normally open. Under these conditions a positional servo circuit exists, causing the integrator potentiometer R_2 to home, preparatory to the next spindle check. When the spindle selector and timer initiates a spindle check, SST_1 and SST_3 open and SST_2 closes. This converts the circuit to an integrator (rate or velocity) servo, until the SST opens SST_2 and closes SST_1, at the end of the alloted integration time. After the integration has been automatically discriminated, SST_3 is closed, homing R_2, the integration potentiometer

Courtesy, Transicoil Corp.

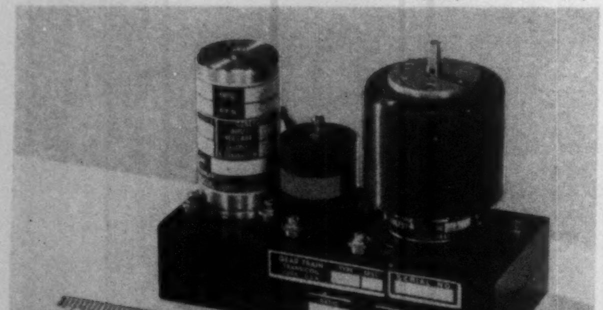


Fig. 14—"Building block" type servo integrator unit. Shown are a 40-turn potentiometer (R_2), motor-generator, and a gear ratio changer for rapid homing. This unit is used with a servo amplifier as in *Fig.* 13

of a bridge circuit, the absolute thrust reaction of any spindle is of less importance than its relative value, compared to other spindles on the head. Of course, "like" duty drills are considered.

If each spindle on a head has its own mechanical feed, it can be readily instrumented at a spindle thrust bearing. Where each spindle has an individual hydraulic piston feed, from a positive displacement, constant rpm pump, the hydraulic pressure would be a direct indication of a developed thrust—a neat method. These arrangements may not be economically practical, except for large machines having but few spindles, or those using large drills.

The use of a separate transducer, amplifier and indicator for each spindle of a multispindle machine, is as obvious a solution as it is an unwelcome one, especially to machinery manufacturers. Fortunately, this can be resolved much more readily than it appears, as follows. Shown in *Fig.* 10 (*a*) is a simple bridge circuit. In this case it could consist of four strain gages. A change in resistance of any arm will develop a voltage at the indicator amplifier input. A number of strain gages can be used in one bridge circuit, as in *Fig.* 10(*b*). Yet, increase of any one strain gage resistance beyond the normal increase experienced by the others (due to normal drill wear) will unbalance the bridge, and excite the indicator or alarm.

An indicator and amplifier would in most cases be needed for each multiple spindle head in an automation-transfer machine, for example. Carbon pile transducers are promising, as they do not require any amplifiers, but they are not "on-the-shelf" items ready for use. Considerable application study would be necessary to use them.

The maximum number of drills that could be monitored by one amplifier and indicator would depend on the slope of the thrust versus dullness curve. This in turn depends upon the feed, speed, temperature, drill, lubricant, and work. These must be determined largely by experimentation.

It should be recalled that dull tool detection is especially necessary for monitoring tools prior to a scheduled general tool replacement. True, by continually, automatically weeding out the early tool failures, the tool changing schedule can be greatly prolonged, resulting in considerable savings and production time. However, there is a statistical point at which it is economically sound to replace all, or nearly all, of the tools in a machine. This is regardless of how long the tools last; eventually they must be replaced. In plain words, automatic dull tool detection does not replace the probability curve, but can in effect negate the early failure probabilities that are the bane of machinery designers and production engineers alike. TABLE 2 summarizes torque methods.

▶ Summing Up

While the squeak, wear land, torque, and thrust, all correlate with tool dullness, only torque and/or thrust are readily instrumented. Either method is applicable to a single spindle machine, but torque measurements require no machine modifications or design changes. As a rule, torque is best determined by drive motor current analysis, and thrust by force sensitive transducers (pickups) at the head of the drill spindle. While the single spindle machine is most readily instrumented, it has the least requirement for it. It does however, show how individual spindles in a multispindle arrangement can be treated.

The big problem is the multispindle machine. There is no pat gadget or solution for the job. However, attacking the problem from both the mechanical and electrical design standpoints will result in success. Each machine is unique.

Torque limiting clutches can be used, but are not readily adjustable to "in-between" settings.

The method of averaging drive motor current, by discriminating integrations, is promising. The success of this method is directly proportional to the time duration of the active drilling cycle, and inversely proportional to the number of spindles driven by a single motor. Integrator systems are illustrated in *Figs.* 11 through 14.

Individual mechanical feeds, or hydraulic feeds, for each spindle, in conjunction with a thrust sensitive transducer for each spindle can be used, but are awkward for a large number of spindles.

An electrical bridge arrangement is especially valuable where several spindles performing like duty are on the same head. By this means, the thrust of any one defective drill is compared to the normal thrust of its identical mates.

The problem of detecting dull tools in multispindle machines can be solved by the joint efforts of machine design engineers and control system electrical engineers. They can be staff members, or consultant specialists.

It requires a complete understanding of the problem, intelligent design, and a modest amount of experimental development.

Having the proper control circuitry necessary to properly sequence and regulate any of the dull tool detection systems discussed above, is as important as the instrumentation.

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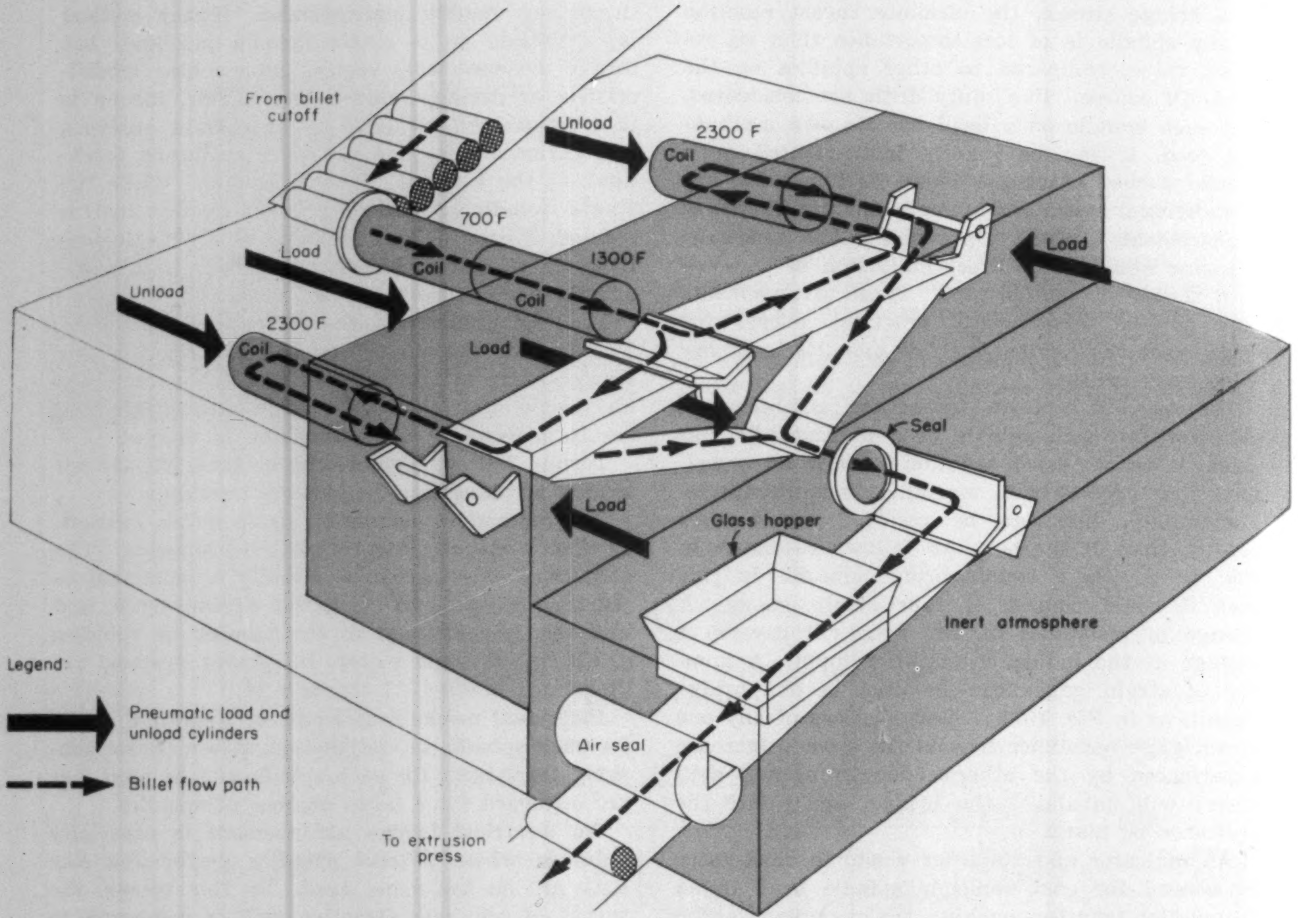

From billet cutoff
Unload
2300 F
Coil
700 F
Load
Coil
1300 F
Coil
Load
Unload
2300 F
Coil
Load
Seal
Load
Glass hopper
Inert atmosphere
Legend:
Pneumatic load and unload cylinders
Billet flow path
Air seal
To extrusion press

Fig. 1—Inert gas atmosphere protects hot billets from oxide formation in special high-speed low-frequency induction heater facility. Billet is heated to 2300F by passing through two of the three coils shown and in final operation is sprinkled with barium chloride salt before ejection to atmosphere

INDUCTION HEATING IN INERT GAS ATMOSPHERE

PROGRESS in induction heating has been stimulated by industry's need for a practical source of localized heat for certain assembly operations, heat treating and, especially, preheating of work for forging and extrusion processes. Augmenting the technical advantages of instantaneous heating response, ease of control and simplified maintenance requirements are considerations important to further use of induction heating equipment in automated operations—the equipment occupies a minimum of floor space and simplified installation requirements permit utilization directly in the production line.

The Magnethermic low-frequency induction heating facility at Jones & Laughlin Steel Corp.'s new hot extrusion plant typifies the use of this type of heating equipment. Round stock of 4 to 5 inches in diameter is automatically cut into billets weighing about 50 pounds each. Billets are placed on a loading ramp for automatic cycling through an induction heater in which billets are heated to 2300F in approximately one minute. This temperature is reached by passing billets through three distinct

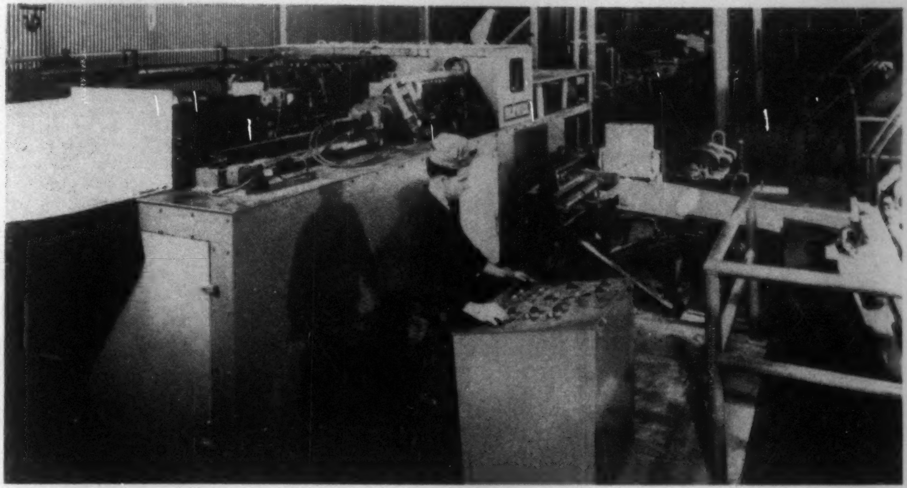


Fig. 2—Induction heater operation is controlled from console type control panel located adjacent to heater and also the hydraulic extrusion press (not shown). Hot billet on table in rear rolls down incline covered with powdered glass which adheres to billet and acts as lubricant in the extrusion operation

heating zones. In the first coil, work is heated first from room temperature to 700F and then at a second position in the same coil from 700F to 1300F. Succeeding billets push work from this first coil to a flipper which alternately directs the pieces to one or the other remaining two coils to be heated from 1300F to 2300F. Properly heated billets are then introduced into a spraying enclosure to be covered with powdered glass or a barium chloride salt which acts as a lubricant in the Ugine-Sejournet extrusion process. From entry into the first coil to ejection after being covered with the powdered salt, processing of the billet takes place in an inert atmosphere to control the formation of oxides which are injurious to dies. From the heater, the hot billets roll to the extrusion press down a ramp covered with more of the powdered salt.

A trouble free handling system is of paramount importance to the continuous use of this billet heating facility. Requisite operational simplicity is effected by a balanced design employing gravity ramps, simple mechanisms, pneumatic cylinders and numerous limit switches. Because of the inert gas atmosphere, billets are introduced into the unit separately through an entrance sealing device which maintains an air seal on the heater. A pneumatic cylinder rams the billet into the first heating zone which in turn causes preceding billets to move one station forward. The partially heated billet moves to one of the two final heating coils by a gravity ramp where it is loaded into and unloaded from the coil by the action of pneumatic cylinders; pneumatically operated mechanisms lower the completely heated billet to another gravity ramp for transfer into the glassing chamber. The coated billet is then ejected from the heater through a rotary reciprocating unloader. Co-ordination of the various cylinders and mechanisms is by means of limit switches.

Thus, it can be seen that as is the case with other types of machines in other industries, an automated handling system has permitted optimum utilization of equipment—a typical example of the advances industry must make if actual operations are to match the theoretical advantages which technological research promises and provides.

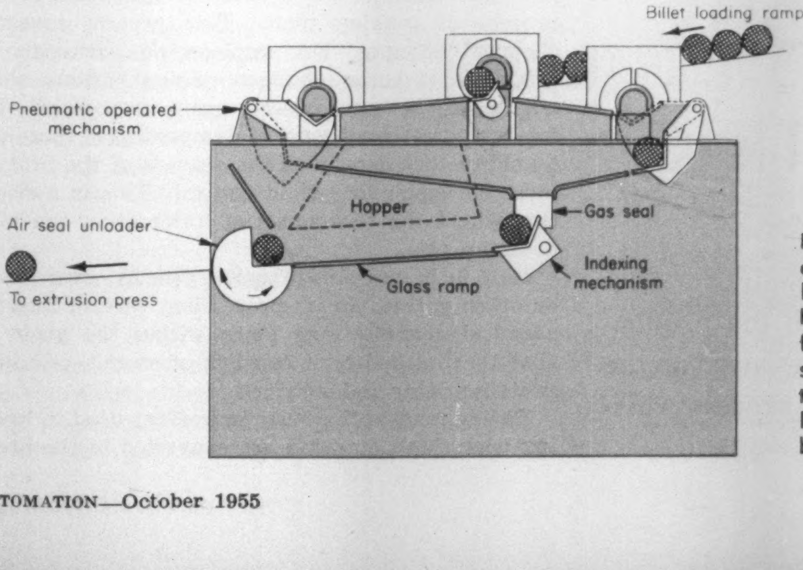


Fig. 3—Schematic indicating ramps and mechanisms used in moving billets from first coil to one of two final heating coils. Billet is then transferred into glassing chamber and subsequently unloaded from heater through air lock. Workpieces are loaded into and unloaded from coils by pneumatic cylinders

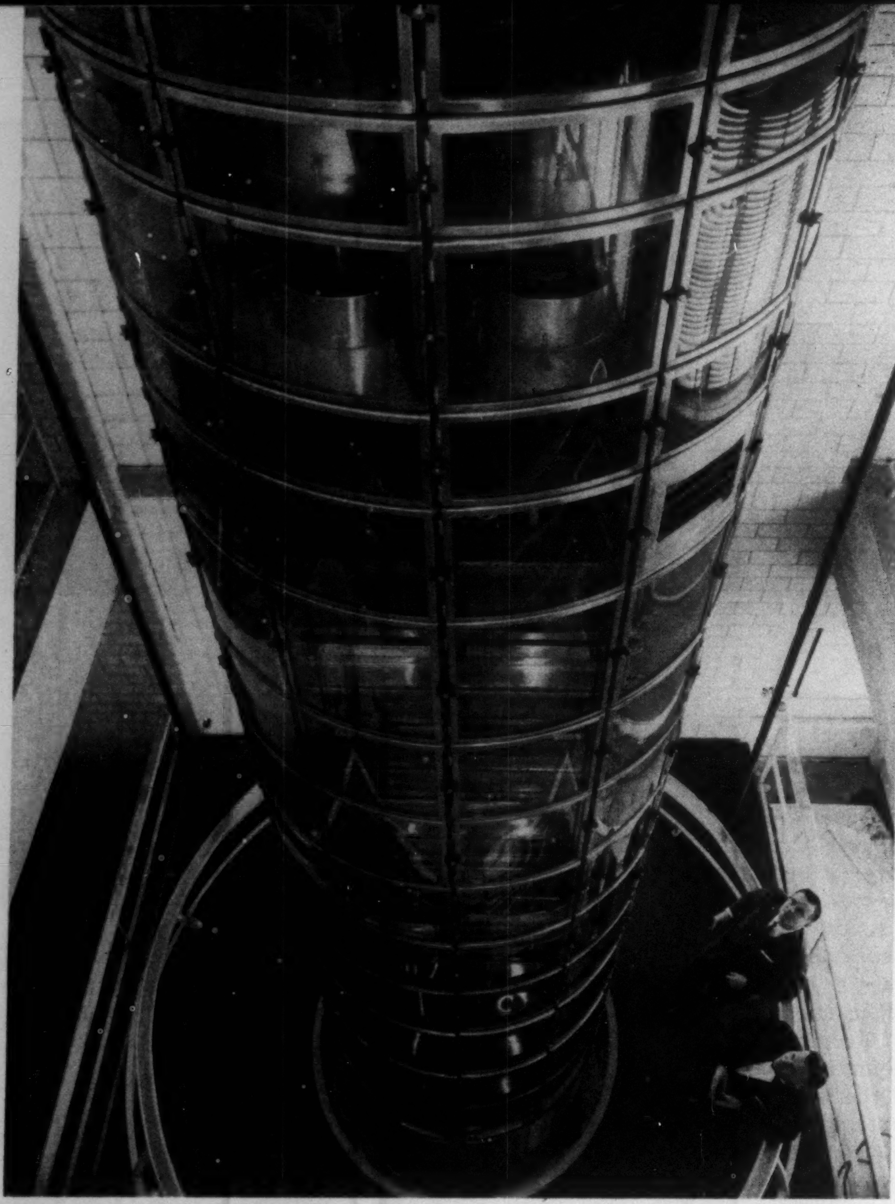


Fig. 1—Pilot malting plant is an exact scale model of the Frauenheim Process refinements to the half century old gravity malting system. It provides for continuous gravity malting by this new process in a tower 26 feet tall by 5 feet in diameter

ADVANCING CONTINUOUS MALTING

Automated pilot plant is built to safeguard top quality, improve the production process, and do basic research on the limitless combinations of process variables

HANDLING AND PROCESSING the foodstuffs of the world is a big business. Bulk processing of grain as a basic food is of particular importance in this industry. Typical of the problems encountered in natural materials is the process of making malt. This process involves chemical changes, but employs no chemicals to bring about these changes. Since various shipments of the unprocessed grain may react differently, the conditions of temperature, time and humidity that determine the success of the process must be kept under rigid control. This is a situation where the techniques of automation can play a major role.

Malt is a processed form of barley, rye, wheat or other grains. In its processing, certain internal chemical changes take place within the grain so that the finished malt consists of starch, cellulose, protein matter and enzymes.

Barley malt is the basic ingredient used in brewing beer. Malt starches are converted in the brew-

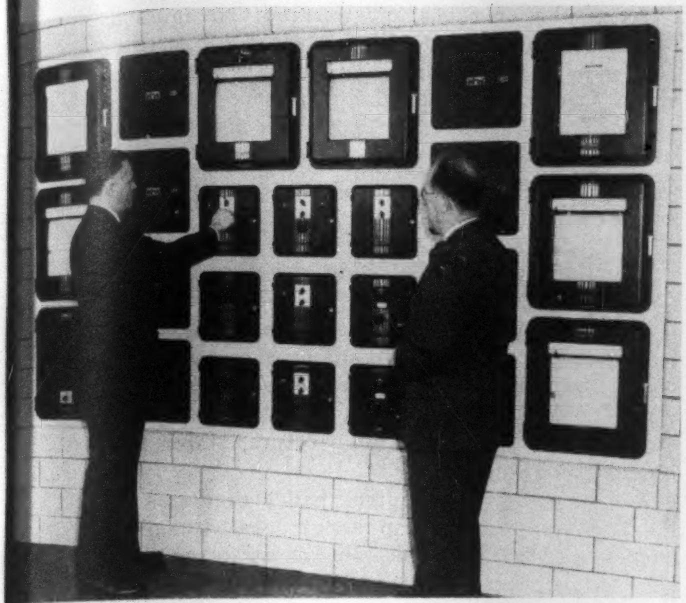


Fig. 2—Nerve center of the completely automatic pilot malting plant is this control panel. Forty-two recordings of temperature and other variables are made here. Controllers actuate 52 valves, gates, dampers and similar devices for the 10 day malting cycle. Edward E. Frauenheim Jr. *(left)*, vice president of Meyer Malt and designer of the Frauenheim Process, is discussing the new installation with B. Robert Segman, chief chemist, who collaborated in the work

ing process to maltose sugar, thereby imparting to beer a distinctive flavor, color, body and aroma. The brewing industry consumes about one bushel of malt per barrel of beer, and because its requirements are over 80 million bushels of barley malt each year, it is malt's biggest customer.

There are many other uses for grain malts in the distilling industry, the pharmaceutical industry and in the food industry for baby foods, breakfast cereals, baked goods, confectioneries, soft drinks and milk shakes.

Briefly, the chemical changes that occur inside the kernel of grain in its conversion to malt come about by permitting the grain kernel to germinate under carefully controlled conditions. Three broad steps make up the entire malting process. First, it is steeped. At this point, the grain is submerged in tempered water for two days so that moisture penetrates thoroughly into each grain kernel. Next, it is allowed to germinate. The steeped grain kernels are placed in specially designed compartments where air of just the proper temperature and humidity is circulated through the grain to maintain exact germinating conditions. The grain "grows" in this manner for six days. At the end of this time, germination is halted by a kilning process in which the germinated grain is lowered into heated kilns and most of the moisture is absorbed from the kernel by the heated air. This last step takes about two days and when completed, the dried kernel is finished malt.

▶ New Malting Process

Over a half century ago, George J. Meyer pioneered the application of the gravity principle to the malting process. An original gravity malting plant was erected at that time and with refinements, has been operating successfully since then. The process and its later improvements are covered by patents.

Early in 1954, the George J. Meyer Malt and Grain Corp. announced the latest refinements to the gravity malting principle — the Frauenheim Process for continuous gravity malting. Its layout places all stages of the malting process in one huge vertical tower. The barley is steeped on two floors at the top, flows by gravity from one to another of the six germinating compartments and moves by gravity into a two-stage vertical type kiln.

All the refinements for accomplishing this feat are now in operation at the present Meyer malt plant. They include three new patented features. Complete gravity flow is made possible by the patented, tower-type arrangement of germination compartments. This is the very heart of the Frauenheim Process. It not only increases the handling efficiency, but assures a full, unbroken kernel. For the brewer this means an increased extract per bushel. Another patented feature provides for the use of reversing air of just the right moisture content and temperature. It can pass through the germinating grain in either direction. By so doing, it assures the most favorable conditions for germination of every kernel—and for exceptionally

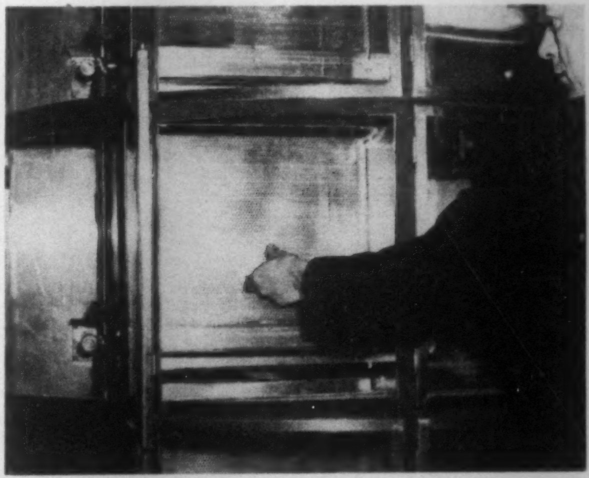


Fig. 3—Stainless steel vertical germinating compartments are the heart of the process. In this pilot plant they have been constructed to scale of one inch to one foot. Shafts and gears at the left are used for turning the germinating grain

fine modification. A third significant patent covers the elaborate grain temperature control system. Controllers maintain the correct temperature in each compartment, thus contributing to malt uniformity.

▸ Pilot Malting Plant

It was decided that if any new advance were to be made in process control and malting research, it could best be done through premalting of adequate barley samples—larger than employed in normal laboratory procedure—but independent of regular production. Consequently, Meyer Malt erected a new four-floor addition to their plant and installed a unique Frauenheim Process pilot malting plant. Its operation is a definite advance into three expanded areas of process control and malting research.

1. **Barley Control**—By premalting in large quantities, the Pilot Plant elaborates on existing safeguards for determining top quality malting barley before barley is purchased.
2. **Process Control**—The increased information from premalting is adapted to the production process for even greater malting control.
3. **Malting Research**—The size, the flexibility, and the automatic controls introduce an almost limitless combination of process variables for probing into all areas of malting.

The pilot malting plant, which was designed by Meyer Malt's vice president, Edward E. Frauenheim, duplicates in principle the Frauenheim Process for continuous gravity malting. Every operation in the process is built to scale, *Fig.* 1, so that the grain is malted under exact production conditions.

The total height of the pilot malting plant tower is 25 feet, 8 inches. The scale is one inch to one foot. The completed pilot plant weighs over four tons, has 168 glass and stainless steel doors, a quarter mile of rubber gasket and five miles of copper tubing and wire. Four different types of malt can be produced at one time. The new construction embodies the pilot plant, the pilot plant control room, and an observation lounge. The whole addition is closely integrated with the modern control laboratory.

▸ Pilot Plant Instrumentation

The Pilot Plant is completely automatic. The Leeds and Northrup Co. equipment on its control board records 42 different variables at one time, *Fig.* 2. It further controls 52 different valves, dampers and gages for temperature, water flow, humidity and air.

For steeping, the control panel regulates the temperature of the steep water; drains, replaces and circulates the water; controls compressors for aeration of the water; overflows the water and drains the tank in a continuous 48 hour cycle. In the germination stage, *Fig.* 3, controls maintain the grain temperature at predetermined, fixed levels for each of the 6 compartments; maintain the humidity at 100 per cent; operate a refrigeration machine; open and close water valves; and record air and grain temperatures. In the final stages of kilning, the controls maintain the temperature in the upper kiln and provide a gradually increased temperature in the second kiln. All fans, blowers, etc., are also automatically controlled.

The complete model is surrounded by a power operated lift, *Fig.* 4, which travels its full height. It is used to transport technicians to any level of the tower for close inspection.

Developments such as this that are founded on experience accumulated over the years, expanded by a recognition of the value of research, and utilize the latest principles of automation are certain to spell advancement for a growing economy.

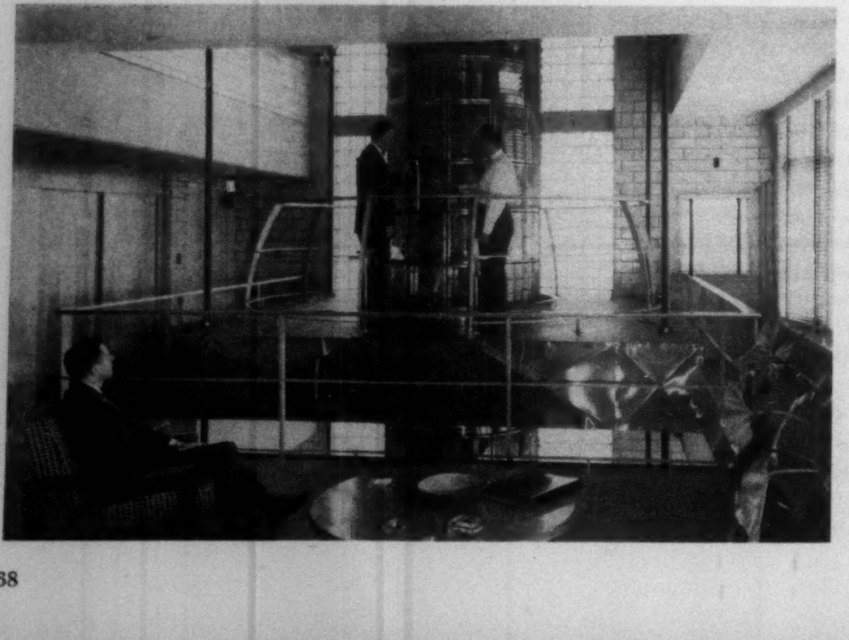


Fig. 4—A specially designed lift, seen here at the level of the observation lounge, carries technicians to any level of the pilot plant for close inspection of the malting operation through any of the 168 glass doors

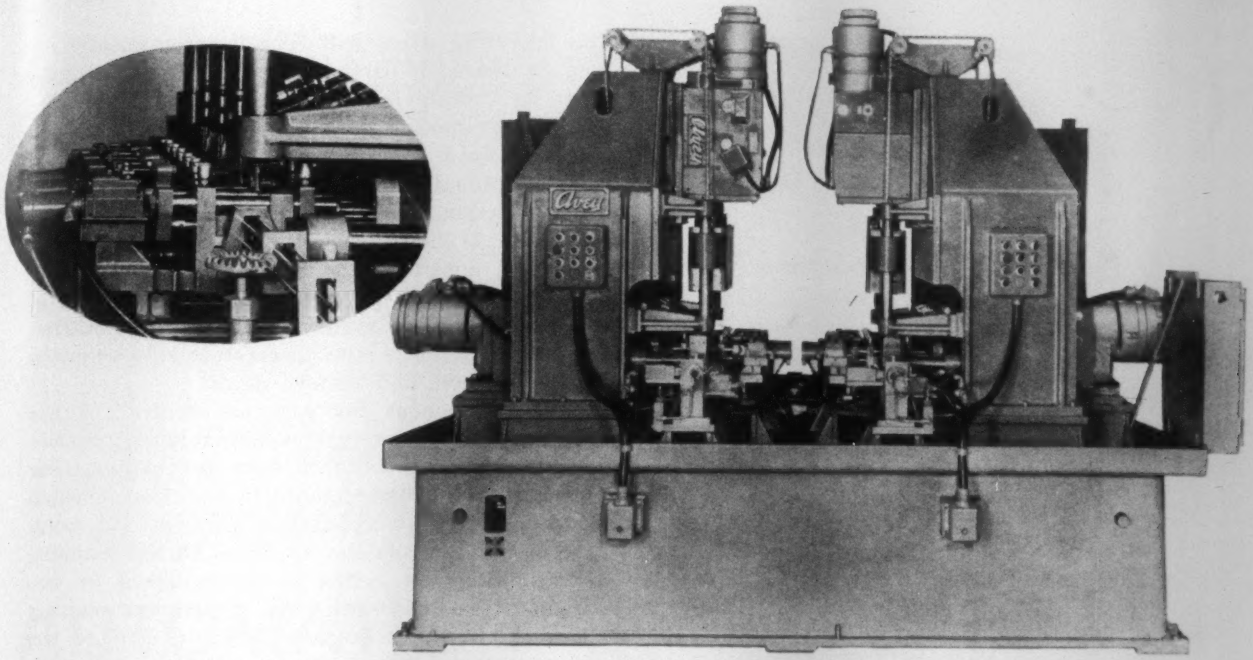


Fig. 1—Each half of this automated machine is an independent machining unit with three stations at which identical drilling and deburring operations are performed. All three stations in each section are fed by a single in-line transfer mechanism for that section. Inset shows the discharge end of one transfer unit

STEPPING SWITCH AND CLEVER HANDLING

AUTOMATE DRILLING AND DEBURRING

HIGH-SPEED PRODUCTION is a practical accomplishment with a combination drilling and deburring machine built by Avey Drilling Machine Co. Approximately 3100 pieces are processed per hour on this machine. The workpiece is an open end hollow cylinder through the wall of which a $\frac{1}{8}$-inch diameter hole must be drilled and the burr removed.

The machine, shown in *Fig.* 1, consists of twin sections mounted on a common base. Each section is independent of the other, and either section may be shut down for service and repair without disturbing the other section. Each half of the machine has a transfer mechanism, a horizontal, cam-fed, 3-spindle drilling unit and an identical, vertical 3-spindle unit for deburring.

Parts are fed down one at a time into each transfer mechanism, which consists of rails defining the transfer path and a hydraulic piston which acts on the last-fed piece to push the line of workpieces along the rails. The piston can be selectively actuated to travel either one or three times the diameter of the workpieces.

This rather unique selective pusher travel is used since a single transfer path, *Fig.* 2, feeds each of the three stations in each half of the machine, and the complete drilling and deburring operation is performed at each station. In other words, three pieces are simultaneously machined indentically in each half of the machine with machining operations being performed at each station on every third part passing through that station.

When a machining cycle is completed, the line of workpieces is advanced three spaces, and the number of spaces between stations is designed so that this movement brings an unmachined piece to each station. During the machining cycle the hydraulic pusher performs two single space movements to refill the feed end of the transfer tracks

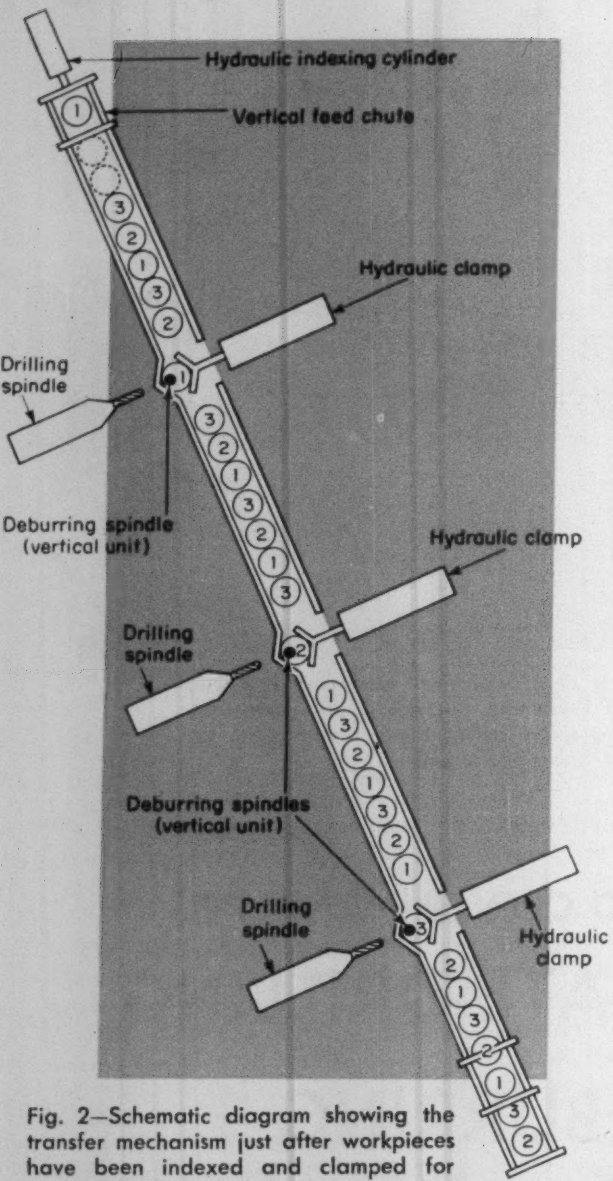


Fig. 2—Schematic diagram showing the transfer mechanism just after workpieces have been indexed and clamped for machining. Two single space strokes of the indexing cylinder will occur before the next 3-space stroke brings three new workpieces into the stations

in preparation for the next 3-space movement. One workpiece drops into position on the transfer track each time the pusher retracts.

Both halves of the machine have the following operating cycle:

1. Advance line of workpieces three spaces
2. Clamp the three pieces positioned in the machining stations
3. Drill the three pieces at low speed
4. Advance one piece at feed end one space (during drilling)
5. Deburr the three pieces
6. Redrill the three pieces at high speed
7. Advance two pieces at feed end one space (during redrilling)
8. Unclamp the machined pieces

The operating cycle will repeat automatically a long as desired if parts are present in the loadin chute to actuate a limit switch there. Provisio is made for another operation to repeat the deburring if desired. Addition of this operation is possible by changing two wires on the control pane of that section.

As *Fig.* 1 shows, each section has its own independent control panel with a common panel, which appears at the right, for the common hydraulic and coolant systems. After he has started the automatic cycle, the operator is only required to change tools and remove chips.

Basic component for sequence control of the cycle is a telephone type rotary stepping switch, *Fig.* 3. Stepping switches used in this machine each have two banks of contacts, the first of which controls the stepping action. The second bank of contacts controls the sequence of the machine actions. Stepping action is accomplished by energizing the switch coil. An interrupter contact operates a relay to break all circuits through the wiper contacts before the switch steps. In this way the wipers are never used to break a circuit. As additional insurance against production delays, a spare stepping switch, completely wired, is used as a stand-by for quick replacement.

For half a century rotary stepping switches have been used by the telephone industry, but only recently have they been applied to an increasing number of industrial uses. Such delay in application of developments in one industry to other industries is all too often the unfortunate result when horizontal channels of communication cutting across specialized vertical areas are not available or are not utilized.

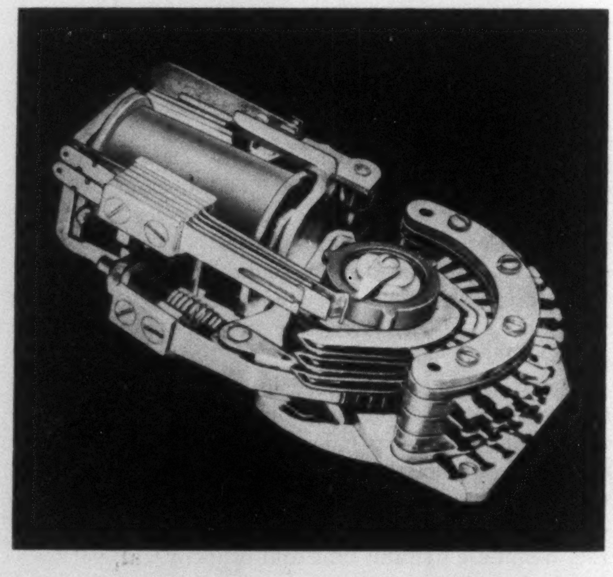


Fig. 3—Major component used to sequence events in each half of the machine is a telephone type stepping switch shown here, supplied by Automatic Electric Sales Corp. This switch should control production of 20 million parts without requiring service other than lubrication

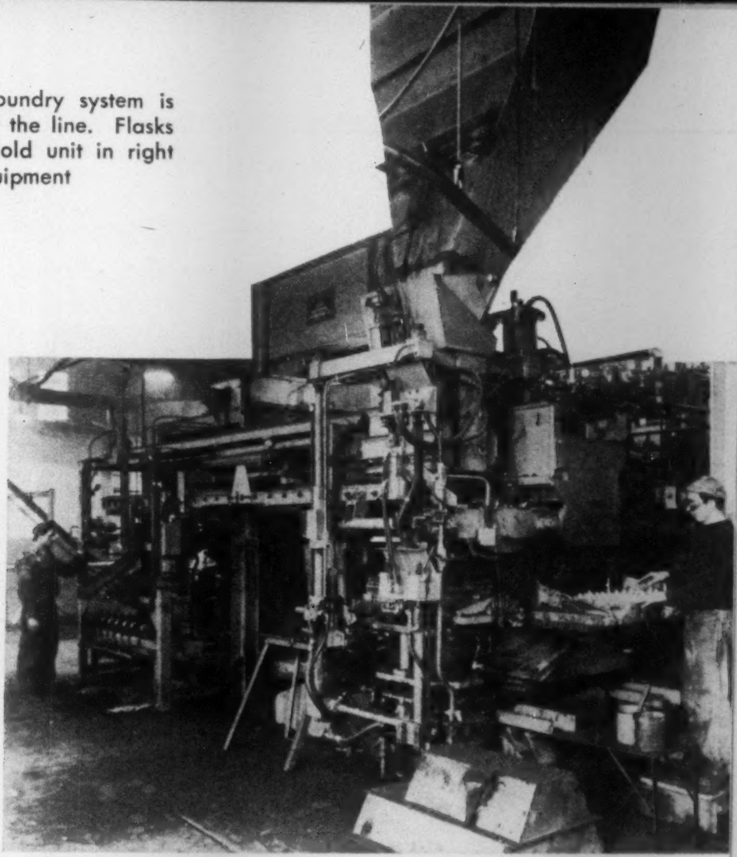
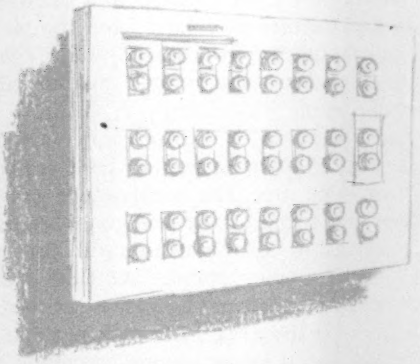


Fig. 1—Compactness of automated foundry system is illustrated by this view of a portion of the line. Flasks move from left toward four-station mold unit in right foreground under sand charging equipment



AUTOMATION IN FOUNDRY

KEYED TO MOLD PRODUCTION

Many of the operations in a foundry meet two of the most important tests in considering the desirability of automation—the various jobs are unattractive from an environmental standpoint and are repetitive in nature. With desirability established, this article covers a most important additional point—feasibility of automation

CO-ORDINATING the various movements and manipulations of the parts of a sand mold during its travel through an automated foundry might appear, at first glance, to present insurmountable problems. But consider the Osborn Mfg. Co.'s packaged automated foundry system at the Eberhard Mfg. Co., *Fig.* 1.

Osborn engineers have conceived a solution involving a closed circuit molding system designed for a set flask length for any specific foundry. Simplified electrical and pneumatic controls are made possible by arranging for flasks to push each other on various conveyors in sequential movement, *Fig.* 2. Movement is obtained through the pusher action of a few strategically located pneumatic cylinders set for a pushing stroke equal to a flask length. In this particular system, Osborn Mfg. Co. was primarily concerned with handling of the mold parts; National Engineering Co. was responsible for the automated sand handling equipment and the Haylco Controls Corp., the sand conditioning equipment.

A plan view of the installation at the foundry of the Eberhard Mfg. Co. is shown in *Fig.* 3. This particular unit is capable of producing 300 molds per hour with a casting weight ranging from one ounce to 2.5 pounds. The number of castings per mold vary from 12 to 60.

In operation, the cope and drag patterns are placed on the molding unit—a four-station indexing machine—which is indexed to a filling position to receive, alternately, a cope or drag flask and a proper charge of sand. From this filling station, the machine then indexes to a molding station where the sand is automatically rammed to the correct compactness. *Fig.* 4. Subsequently, the prepared molds are then indexed to a drawing station where the pattern is drawn from the mold and the mold is ejected onto a flanged roller conveyor.

Ejection of subsequent molds pushes all preceding molds along the conveyor. A limit switch controls the operation of a drag rocker mechanism such that cope halves of molds continue on the original conveyor but the alternately positioned drag halves are turned over and down on another conveyor set at a convenient height for manual placement of necessary cores. At this point, the cope half, with pattern cavity down, is located on one conveyor and the drag half, with pattern cavity up, is traveling on a lower second conveyor, *Fig.* 5.

After the coring station is a closing station consisting of a pivoting mechanism which swings the cope half of a mold from the upper conveyor and closes it on the drag half, *Fig.* 6. Every two completed molds ejected by the closing mechanism are transferred, by means of a pneumatic cylinder, to a station where the pair of molds are positioned on a pallet; molds are then brought into contact with a weight setter mechanism which holds the molds together during the pouring operation and for as long as necessary during the cooling period.

After pouring, *Fig.* 7, successive pallets push each other along a cooling conveyor, the length of which has been determined by type of work being processed in the particular foundry. At the end

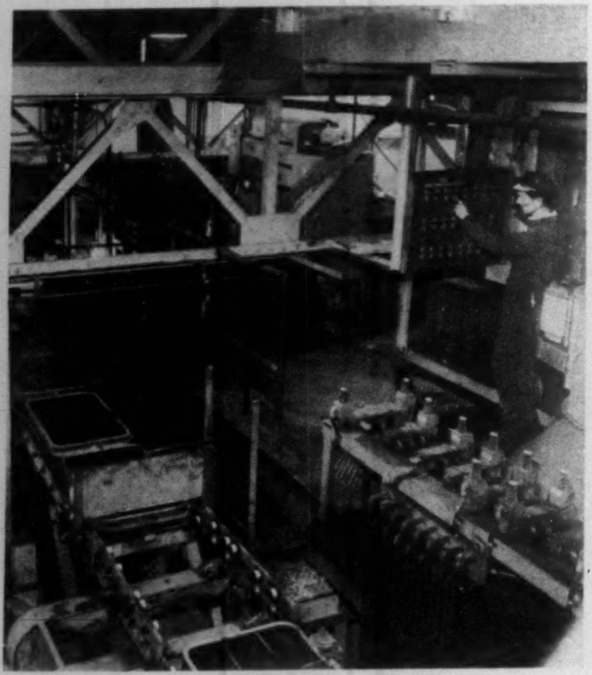


Fig. 2—Control of system is accomplished from central panel. Special solenoid actuated valves in right foreground control operations of various pneumatic cylinders through sequencing action of timing cams in electrical circuit

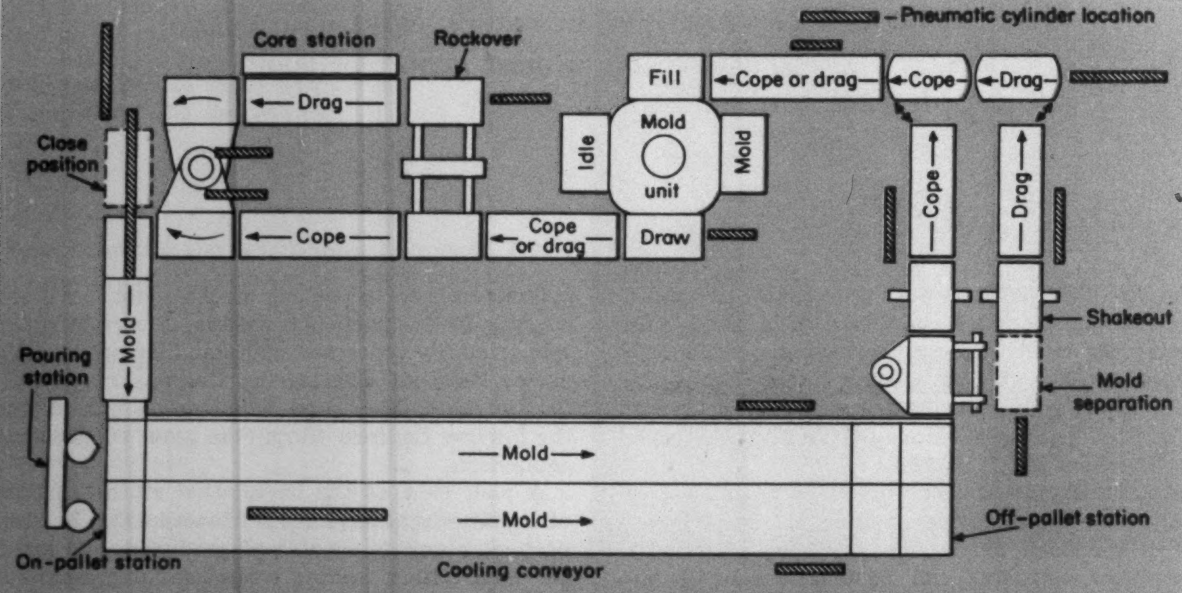

– Pneumatic cylinder location
Core station
Rockover
Drag
Cope
Cope or drag
Fill
Mold
Mold unit
Idle
Draw
Cope or drag
Cope
Drag
Close position
Mold
Pouring station
Shakeout
Mold separation
Mold
Mold
Off-pallet station
On-pallet station
Cooling conveyor

Fig. 3—Plan view of installation at Eberhard Foundry which can produce 300 molds per hour. System is designed in multiples of a flask length for simplified co-ordinated control of movement achieved by use of various pneumatic cylinders

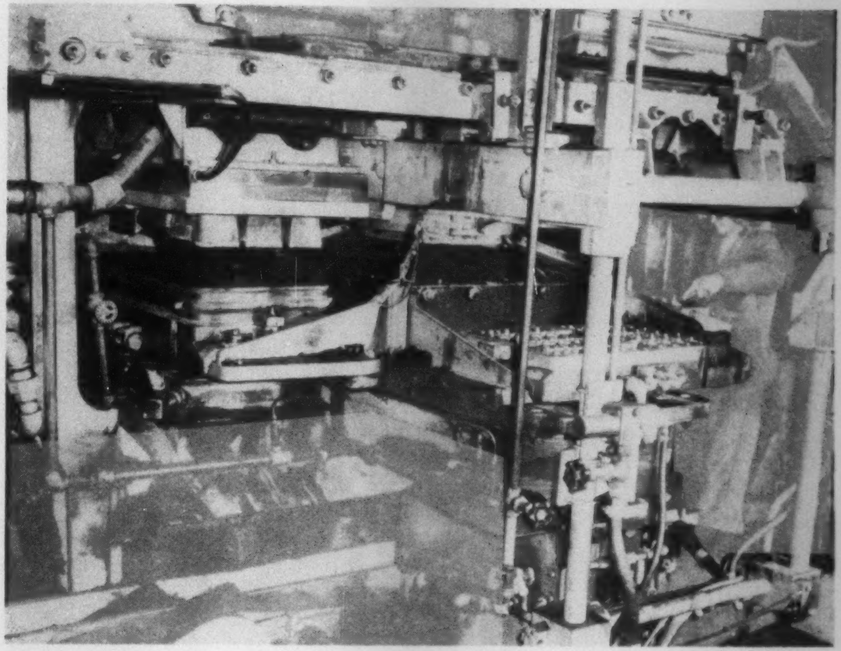


Fig. 4—Alternately, cope and drag flasks come into position over proper pattern; the pattern table moves upward under the flask and is automatically filled with proper charge of sand. After the filling operation, the machine indexes filled mold to second station (left) for ramming

of the cooling run, the molds are slid off the pallet which is returned to the pouring station by the return section of the same conveyor which carried the poured molds through the cooling run.

An elevator mechanism receives the poured molds and lifts them to a suitable height for transfer to a conveyor leading to an automatic shakeout machine, *Fig.* 8. One at a time, the molds are received at the shakeout area and cope and drag halves separated. Drag half is rocked over to facilitate casting and sand removal. After the sand recovery operation, the two halves of the mold are in a position to commence a new cycle at the mold preparation unit.

With the exception of core setting and pouring, which are manual operations, the entire system can be controlled by one man through a central control panel. Of interest, in addition to the re-

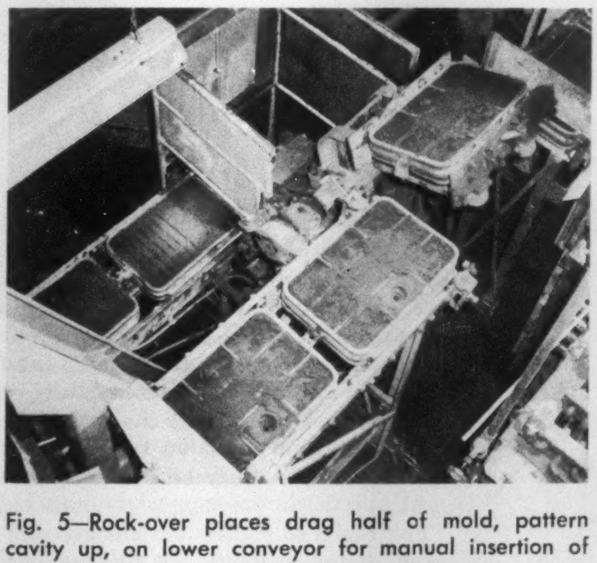


Fig. 5—Rock-over places drag half of mold, pattern cavity up, on lower conveyor for manual insertion of necessary cores prior to closing operation

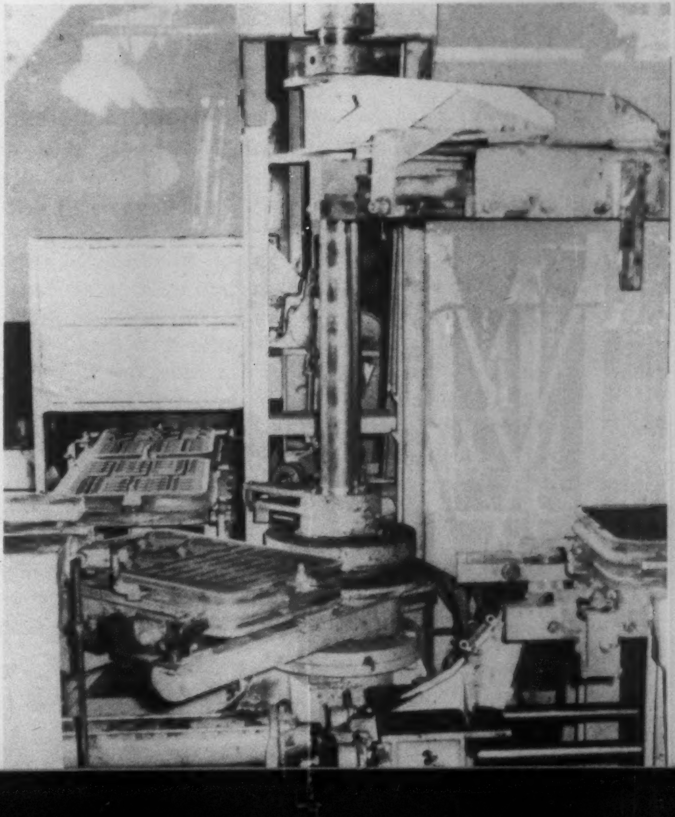


Fig. 6—After cores are set, closing mechanism pivots to bring both parts of mold into position for closing. Note cylinder, lower left, which pushes completed molds to pallet loading area prior to pouring operation

markable production rates achieved with this automated system, is the saving in floor area. As an example, the Eberhard installation occupies approximately one-quarter of the floor area which would be required in a typical foundry in accomplishing an equal rate of production.

One other important point warrants a comment. Though it is generally thought that job-shop type of production does not lend itself to automation, this particular system illustrates an important exception. The unit of work being automated is not the end product being manufactured (castings) but the component parts of a standard size mold. As the design permits rapid change over of patterns, any job-shop quantity of parts can be made without disturbing the benefits realized from automating the molding process—the result is an automated job-shop production facility.

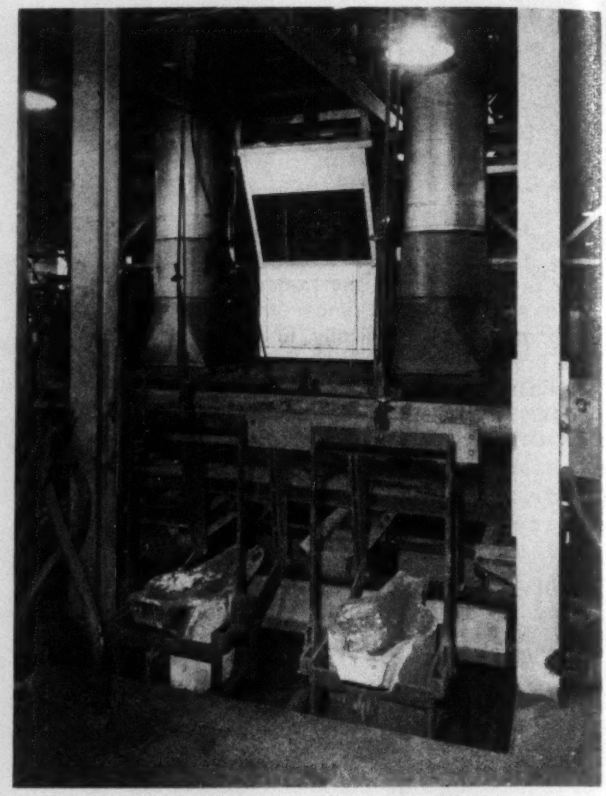


Fig. 7—Not yet in operation, remote control of pouring will be controlled from central point overlooking entry into cooling tunnel

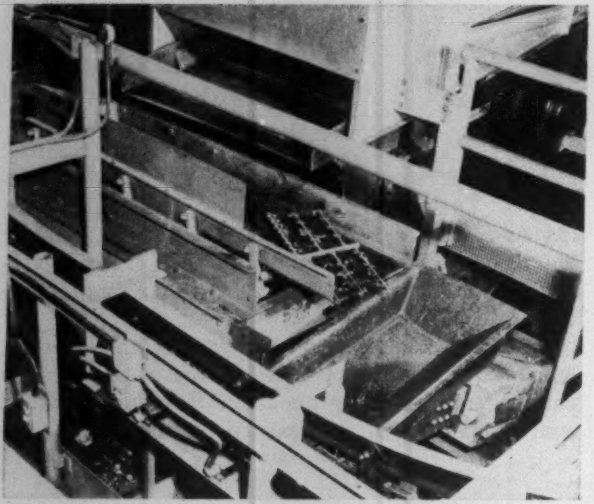


Fig. 8—Automatic shakeout recovers castings. Parts are vibrated onto trolley conveyor for transferral to cleaning area. Empty flasks are fed back into molding machine to start new cycle

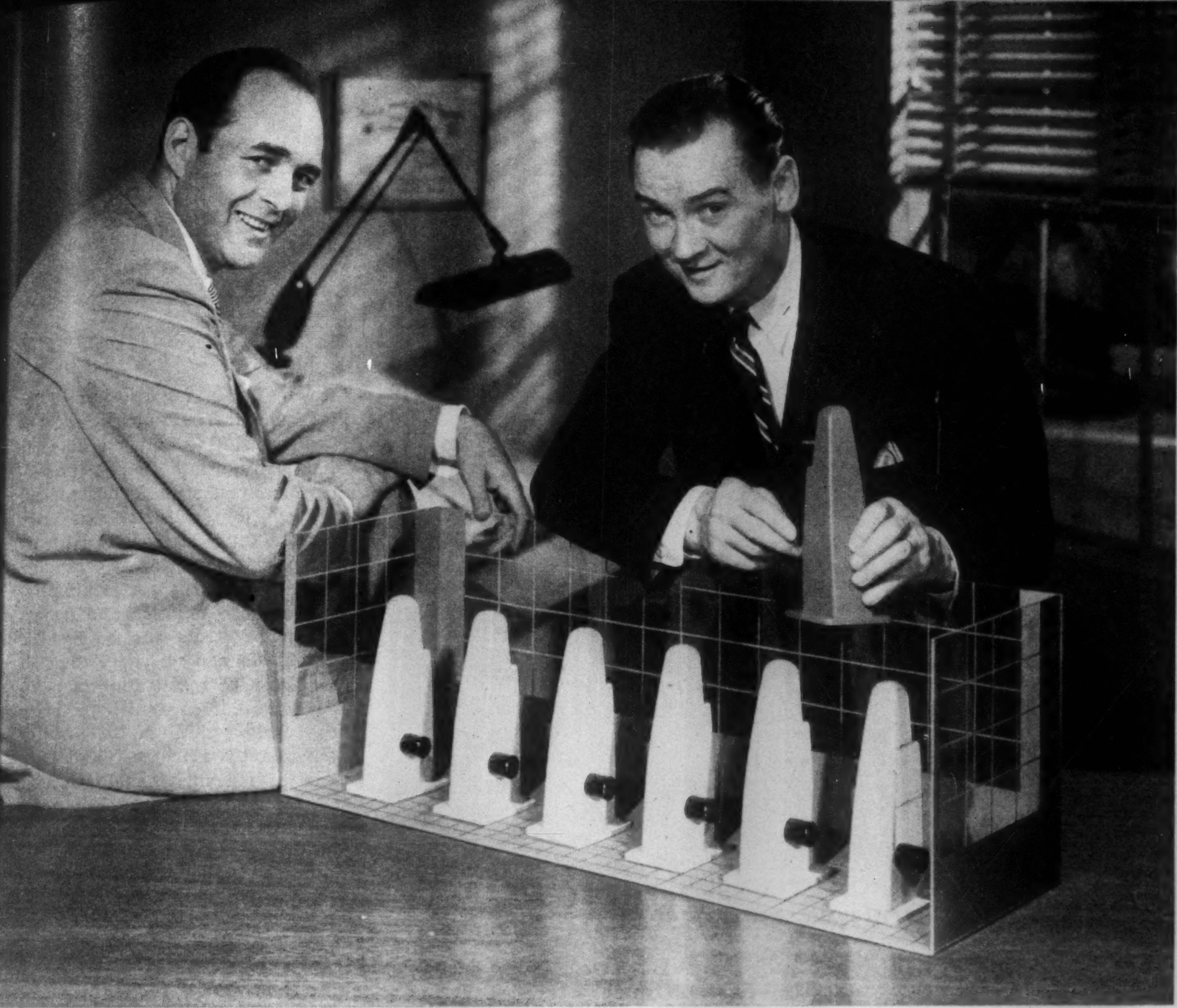
—CONTROL BY DIGITAL COUNTER

DIGITAL controller developed by American Electronic Mfg. Inc. can be applied to wide variety of industrial control problems. Typical applications include control of machine tool operations, conveyor belts, and batch mixing operations. Unit has capacity of 2500 counts; it adds and subtracts at rates up to 20 decimal digits per second with an accuracy of 0.04 per cent. The count at any instant is shown on four illuminated windows by a new type of indicator tube known as the Inditron.

Set of switch controls on the front panel of the unit provide for presetting any four digit number, positive or negative, up to 2500. An output signal is obtained from the controller when this preset number is reached by an incoming pulsating signal.

As an example of a typical tool application, the controller is used on a line of stretch-forming machines of Sheridan-Gray Inc. An operator first manually operates the machine through a complete cycle with the controller indicating pulse counts received from special transmitter during the cycle. Succeeding pieces are loaded into the machine and operations are then automatically controlled by presetting the determined count into the controller.

The problem of counting items on two conveyor belts, one belt feeding the other and both operating at different speeds, is frequently encountered in industry. Photocells or similar devices are commonly employed in the system. If, for example, the count on one conveyor is 10 items per second, and on the second belt 20 items per second, the controller receives pulses from the photocell-transmitter at one belt up to a count of 10; it then starts the second belt. At the count of 20 from the second photocell-transmitter, the second conveyor belt is stopped automatically and the first belt is started again.



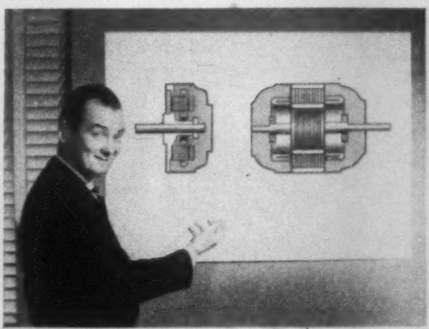
hey wanted to add another machine on the line

Fairbanks-Morse Design Engineers wanted to see how *you* could get more production out of every square foot of premium production line space.

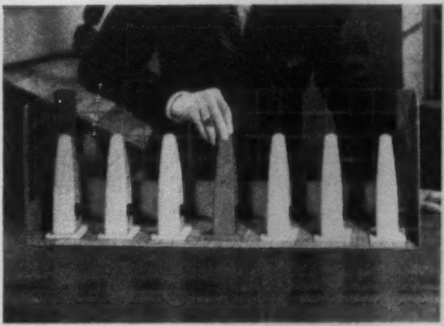
They designed the now-famous Fairbanks-Morse Axial Air Gap Motor that is much shorter than conventional type motors. That saved "motor space" can become "production space" by the addition of one or more machines to every production line.

It is this kind of design approach that typifies the product bearing the Fairbanks-Morse Seal of Quality. When next you look for an electric motor . . . a scale . . . a pump . . . a diesel engine, look for the F-M Seal and see the difference that quality makes.

Fairbanks, Morse & Co., Chicago 5, Ill.]



The Secret . . . is that the air gap in this motor is perpendicular to the shaft, rather than parallel as in a conventional motor . . . without sacrifice in performance.



The Result . . . is that by replacing conventional motors with F-M Axial Air Gap Motors, enough space has been saved to add one or more machines to the line.

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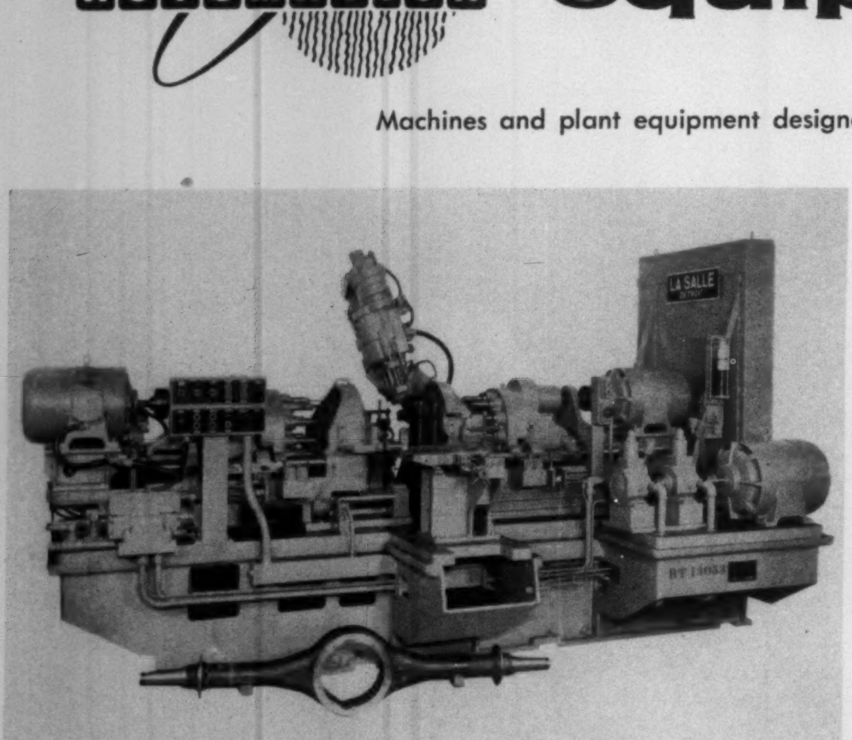

ADJUSTABLE HOUSING PROCESSOR

Any one of six different housings can be processed on this self-contained drilling machine, with no additional locators required. Operations can be varied to suit a particular housing by adjustments which are direct gage settings for each of the six housings. Machine eliminates handling and set-up normally associated with this drilling operation. Housing is placed in preload position, machine carries part to the work station and through complete cycle of operations when cycle button is pressed. Endwise location is taken from a flange, and is adjustable to suit particular housing. Up and down location is taken from bearing diameters and is also adjustable to suit the part. Vent hole drilling unit of the machine is mechanical and cam operated. It is adjustable by gage setting to accommodate various contours of six different rear axle housings which can be processed on machine. Twenty holes are drilled automatically in the housing—ten from each side—along with one vent hole. Hydraulic and coolant tanks are contained in base to save floor and work space. Electrical panel is mounted to base. Coolant is piped into each bushing plate and manifolded to point of application. **LaSalle Tool Inc.**, 3840 E. Outer Dr., Detroit 34, Mich.

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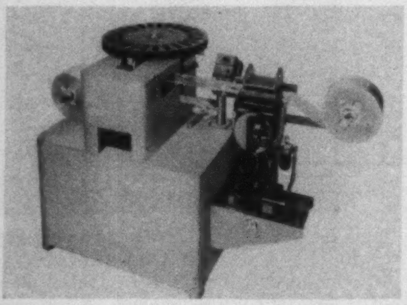

PRINTER AND PACKAGER

Trademark, product description or control number can be imprinted on packages simultaneously formed, filled and heat sealed by new machine. Equipped with a Markem printing unit, machine automatically prints flexible two-dimensional packages, formed around product from roll stock at rates up to 3600 per hour. Vertical feeding principle permits packaging single items or assortments. Variety of both uniform and irregular shaped items can be handled without change or adjustment of feed. Positive registration of package imprint is assured by printing head cycling through limit switch activated by machine. Other features of machine include variable speed drive, automatically controlled sealing pressure and temperature, and automatic safety features. **Pak-Rapid Inc.**, 530 N. 21st St., Philadelphia 30, Pa.

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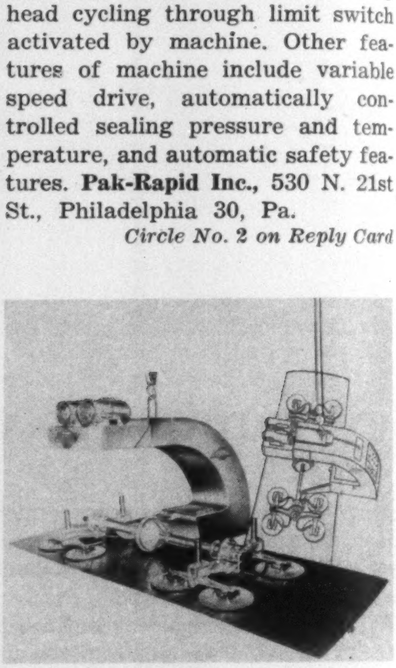


SHEET LIFTER

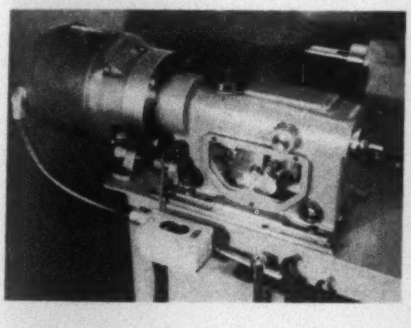
Designed to handle sheets of any nonporous material up to 5 ft wide by 20 ft long weighing 2000 lb—with a 7 to 1 safety factor, sheet lifter is equipped with a U-hook for attaching to an overhead crane. Sheets may be moved to any location in plant with safety. Lifting of sheets is accomplished by vacuum produced by two pumps. Vacuum is drawn through tubes and a storage tank to eight rubber cups.

No pinch bars to separate sheets or grappling hooks for lifting load are needed. Feature of sheet lifter is ability to rotate sheet 180 degrees. Sheet or plate when inverted can be carried with safety and without dependence upon vacuum. Rotation may be stopped at any angle from horizontal to 180 degrees, facilitating inspection of both sides of sheet and providing means of vertical stacking of sheets. Larger vacuum sheet lifters are available to lift sheets or plates weighing up to 4000 lb. **F. J. Littell Machine Co.,** 4127 Ravenswood Ave., Chicago 13, Ill.

Circle No. **3** *on Reply Card*

CAM FEED UNITS

Furnished in four sizes, line of cam units up to 5 hp capacity is designed to drill, ream, tap and mill. Each unit is self-contained; power is derived through single motor with no air or hydraulic pressure used. Units can be mounted in any position and any number of units can be used. All four sizes are cam controlled. Standard equipment with each unit includes four standard cams and complete sets of cycle change gears. Feeds and speeds within ranges are of infinite variation, and charts are provided to aid in selection of proper speeds. Four drives are furnished: cone pulley, direct motor, stub shaft or gear box. Oiling systems are self-contained. With four sizes, drill size range is from $\frac{3}{8}$- through 2 inches. Cycle time ranges from 2 through 410 seconds. Stroke range is from $2\frac{3}{8}$ through 5 inches. Spindle speeds range from 300 through 4032 rpm. **Zagar Tool Inc.,** 24000 Lakeland Blvd., Cleveland 23, O.



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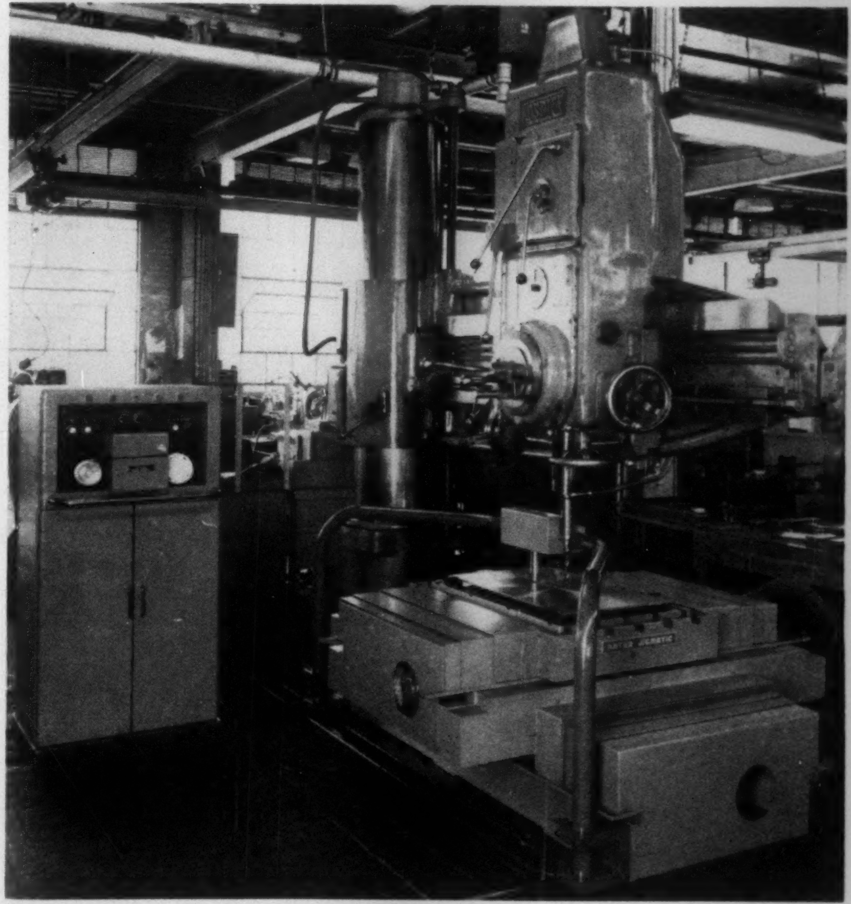


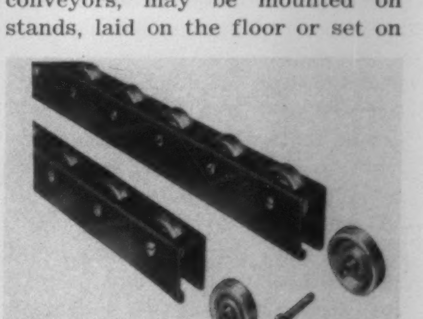
TAPE CONTROLLED WORK POSITIONING DRILL

Electronic punched tape control positions work automatically for any number of holes in new drilling machine called Jigmatic. Punched tapes are prepared from engineering drawings. Operator positions work properly with respect to table's X and Y axes, feeds tape into reader on electronic control console and drills holes. By providing fully automatic, punched tape control of work positioning for drilling, Jigmatic cuts down-time and is adaptable to 4 ft or larger radial drills or other suitable drill spindles. Machine has no stops or dogs to set. **Arter Grinding Machine Co.,** Worcester, Mass.

Circle No. **5** *on Reply Card*

STRIP CONVEYOR

Called Rapistan flow track, lightweight gravity wheel strip conveyor is available in two standard sizes, each with a choice of three wheel spacings for handling wide range of materials. Feature of conveyor is method of wheel mounting to give two-point axle support to provide maximum resistance to bending under loads. Lock nuts hold wheel assembly securely, and wheel bearings are lubricated for life. Standard 10-ft section of flow track with supports on 5-ft centers can distribute load capacity of from 400 to 750 lb and weighs only 15 to 24 lb. Applications of conveyor include handling packages, cases, cartons, pallets, sheet stock, cylindrical objects and other materials in production or warehousing operations. It can be used with other types of conveyors, may be mounted on stands, laid on the floor or set on



work benches to reduce manual handling. **Rapids-Standard Co. Inc.,** Dept. FT, 342 Rapistan Bldg., Grand Rapids, Mich.

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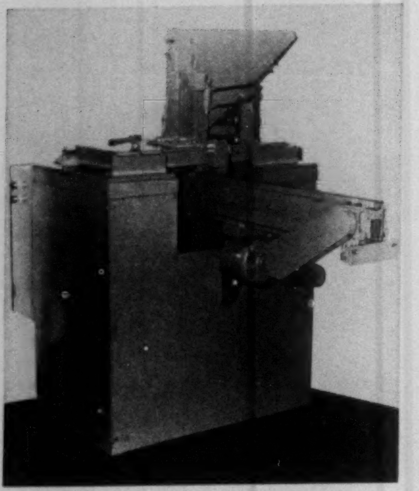
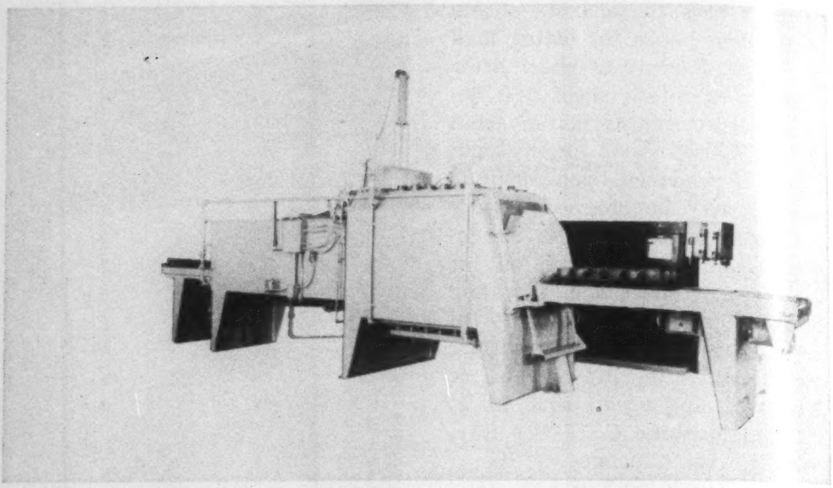


AUTOMATIC GRINDER

New combination provides automation in grinding and polishing operations. Adjustable shaft hopper and adjustable chain feed conveyor handle a range of sizes of shafts or any long cylindrical piece parts. Both hopper and conveyor are mounted on rollers on a floor stand, while the other end of the conveyor is bolted to the grinder work rest slide. Therefore, as the grinding wheel wears, hopper and conveyor are maintained in the correct relationship. For tandem grinding setups, conveyor can be equipped with special guide plates which present the parts to the grinder in precise alignment, even though the grinders have unequal wheel wear. **Kraus Design Inc.,** 977 Exchange St., Rochester 8, N. Y.

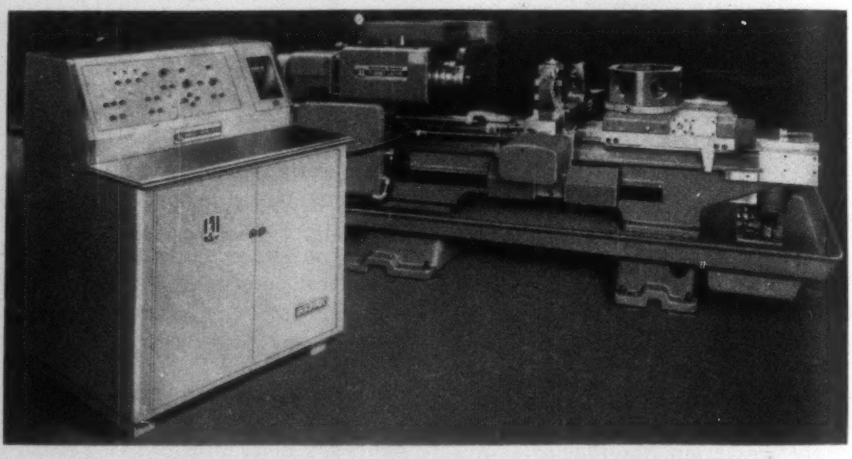
Circle No. **7** *on Reply Card*



HEAT TREATING UNITS PROVIDE AIR COOLING

Three heat treating units feature multiple cooling zones for air-cooling of work in protective atmospheres. Units make possible carburizing, carbonitriding, normalizing, annealing, stress relieving, and brazing operations under atmosphere protection to achieve bright, scale-free work. Applied to the cooling zones, unit provides scientific control of both heating and air cooling cycles under high production conditions. Units are classified at 400, 500 and 900 lb per hour at 1500 F. Maximum weight per charge is 600, 800 and 1400 lb respectively. Operating temperatures of 1850 F or 2150 F are available. In operation, work is loaded directly into the heating zone, and after the proper time at heat, is transferred automatically to the cooling zones by Cold-Chain transfer. **Ipsen Industries Inc.,** Rockford, Ill.

Circle No. **8** *on Reply Card*



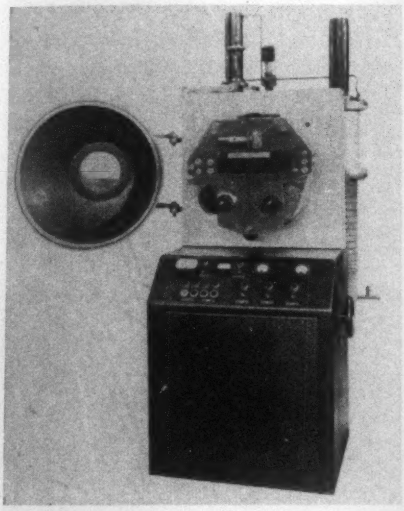
NUMERICALLY CONTROLLED TURRET LATHE

Completely controlled by a punched tape, machine is automatically cycled and provides rectilinear motions with precise controls to end points. Tape also controls spindle speed—choice of 32 speeds—16 in high range and 16 in low range; indexing of six-position turret to any face at any time; indexing of four-position turret to face at any time; operation of hydraulic powered collet chuck and bar feed; turning coolant on or off; opening or closing hood; and resetting of tape to repeat cycle. Tape uses binary number coding for maximum use of tape space. Tools are preset to gages for given dimensions. Combination makes it possible to obtain a drawing, code necessary information, punch a tape, plug in preset tools and make part without further tool adjustment. Machine is well suited for short run jobs, even single piece production; at the same time automatic cycle allows turret lathe multiple tooling on long runs, thus extending range of turret lathe operations. **Jones & Lamson Machine Co.,** 40 Woolson St., Springfield, Vt.

Circle No. **9** *on Reply Card*

VACUUM METALLIZER

Designed for continuous roll metallizing, single-chamber, vacuum metallizer features faster metallic coating of plastic film and sheeting, such as Mylar, acetate, cellophane, butyrate, and even thin sheet steel. Units have a single vacuum chamber and thus need only a single vacuum pumping system. Metallizing units can coat material in widths of 6, 24, 36, 48, 54, or 60 inches, at speeds up to 500 ft per minute. Rolls up to 24 inches in diameter can be accommodated in units, and material ranging in thickness from 0.0005 up to 0.0020-inch can be successfully coated on a continuous basis. Units are designed to deposit a brilliant, uniform coating of metal over entire width of material with no dark or burned areas. An observation port set into cover of unit, plus a fluorescent light source placed behind coated film allows operator to check uniformity and quality of coating continuously during deposition process, and to adjust speed of travel of material through evaporation chamber to obtain desired thickness of metal deposit. Air actuated poppet valves, pushbutton controlled from front panel, simplify operation of units. Other uses for continuous roll metallizing include condenser paper for production of capacitors, decorative wrapping papers, metallic string and textile fabrics. **F. J. Stokes Machine Co.,** 5500 Tabor Rd., Philadelphia 20, Pa.



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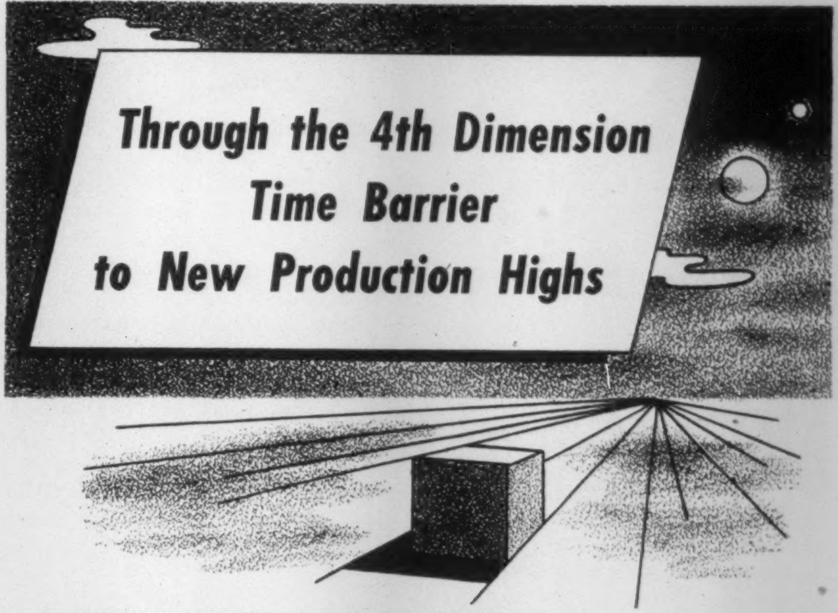


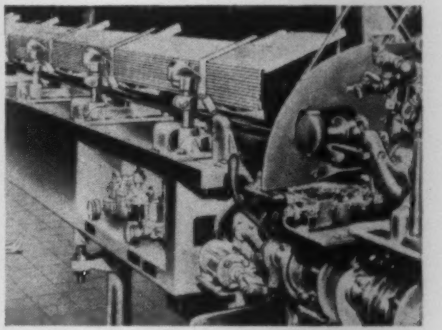
LIPE AML BAR FEED

gears machine production to the steady flow of Time

ALL industrial results are achieved in Time . . . *vital 4th dimension that measures output, costs, profit.* Shorten the time gap between operations . . . shorten the time when machines are "cutting air" . . . keep machines producing at a steady optimum rate during the fatigue slow-down from 10:30 to noon, and from 3 P.M., till closing time . . . *and you are getting 4th Dimension production.* Production that is geared to the steady flow of Time.

Lipe AML Bar Feed Produces from 30% to 100% More Output by Eliminating Time Losses . . .

Time losses account for the enormous differences in output among workmen. By eliminating these losses automatically, the Lipe AML Bar Feed boosts overall production from 30% to 100%. That's because stock is fed to the machine independent of the operator. Constant pressure behind the stock assures uniform speed of feed. No feed fingers to fail or mar stock. No multiple feed-outs, even on the longest pieces.



Mail the coupon now for free literature giving full details on the Lipe AML Bar Feed.

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Syracuse 4, N. Y.

Sure, I'd like to know more about the Lipe AML Bar Feed. Send me your free booklet.

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Company________________
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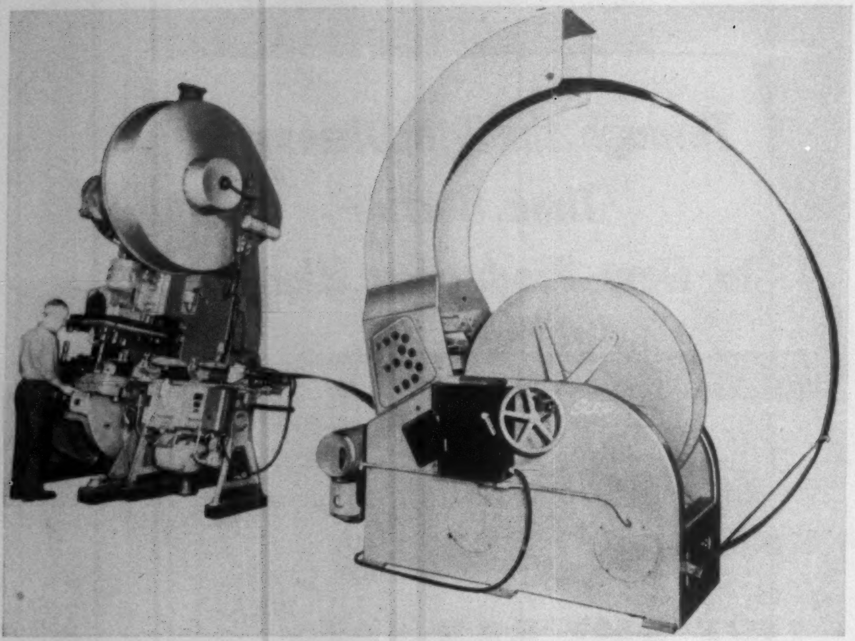


COIL STOCK CRADLE AND STRAIGHTENER

Designed to save floor space in press rooms, combination cradle and straightener features a reverse loop design. Loops of stock are directed over the coil by means of an upright stock guide and under the coil by an internal stock guide. Coil stock is carried on two powered rollers which are mounted in self-aligning ball bearing pillow blocks. Rotating side plates hold coil stock in place and provide alignment with the press. Straightener will handle stock up to 3/16-inch thick, and consists of two sets of pinch rolls and five straightening rolls.

New unit has a four to one variable speed drive motor which is automatically stopped and started by a loop control arm. **Special Equipment & Sales Co.,** 3949 E. 9 Mile Rd., Hazel Park, Mich.

Circle No. **11** *on Reply Card*

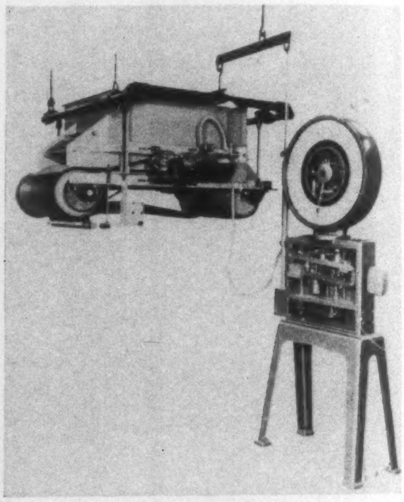
STRAPPER AND SEALER

Designed to strap and seal packages of various sizes, electrically powered machine automatically applies and tensions the strap, makes and crimps its own seals and cuts the strap. Depending on size of packages banded, machine will make up to 1000 ties per hour. Packages of different sizes and contours can be banded one after another without adjusting machine. Strapping tension can be adjusted in seconds. Machine, which is called the Autobinder, makes its own seals from a coil of special steel. Reel for dispensing the ⅜ by 0.015-inch steel strapping is furnished with Autobinder. Banding machine can be installed in production lines for added speed in packaging. Package with a minimum width of 7 inches and up to 20 by 22 inches can be strapped on Autobinder. **A. J. Gerrard & Co.,** 1950 Hawthorne Ave., Melrose Park, Ill.

Circle No. 12 on Reply Card

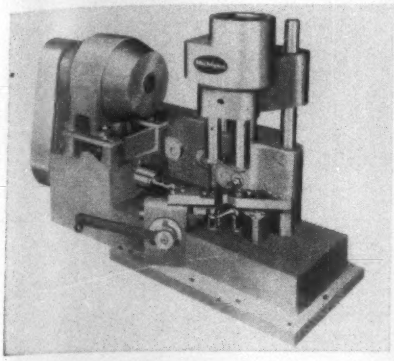
DIFFERENTIAL SCALE

Automatic scale weighs sticky and non-free flowing materials as accurately as dry aggregate materials. Unit automatically and continuously delivers a selected amount of material, the weight of which is a set difference between a fully loaded and partially loaded scale. Called a weigh-in and weigh-out scale, unit is made up of a weigher, dial scale and totalizer. Weigher, consisting of weigh hopper mounted on a short belt conveyor, is suspended from levers terminating in dial scale. Belt conveyor provides a live bottom for weigh hopper, and facilitates discharge of hard to handle material. Scale is suitable for weighing adhesive materials which cannot be weighed accurately by conventional scales. Among materials also handled by unit are chemicals, foods, fertilizers, cement and rock



products. To start a weighing cycle, operator feeds material into weigh hopper by pushing a start button located on remote panel board. As hopper is being loaded, dial scale pointer moves up and round dial until batch weight plus tare weight is shown to have been deposited in hopper. Feeding then stops. After dial pointer steadies itself momentarily, belt on weigher goes into operation, discharging material as it moves. As material drops from weigher, scale pointer moves back down dial until tare load has been reached. At this point, belt stops and required amount of material has been discharged. Totalizer which may be located next to dial scale or remotely, indicates this weight. Cycle then automatically repeats itself. **Richardson Scale Co.,** Van Houten Ave., Clifton, N. J.

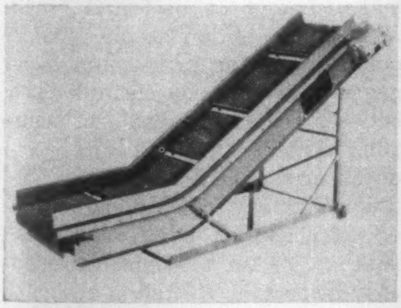
Circle No. **13** *on Reply Card*



TWO-WAY DRILL UNIT

Right-angle drilling on any standard drill press is possible with self-contained drill unit. Units are locked to drill press by a cam wedge, either manually or automatically. Pressure from vertical unit, while drilling, advances horizontal unit. Feeding of cross or right angle is accomplished by rack and pinion gears. Moving parts are lubricated automatically by means of a reservoir built into the unit. Illustrated unit drills four holes in a gear shift lever. Only three spindles are actually drilling the four holes—two vertical holes and one right-angle hole through split clamping arms. Additional spindles can be provided for either vertical or horizontal drilling. **Michigan Drill Head Co.,** P.O. Box 4643, Detroit 34, Mich.

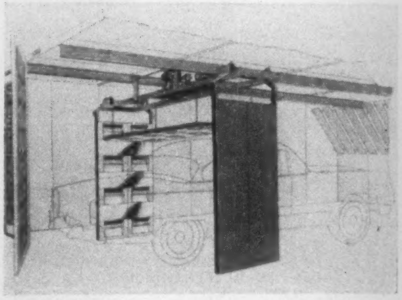
Circle No. **14** *on Reply Card*



ADJUSTABLE CONVEYOR

Used in foundries, forging plants and parts warehouses, adjustable conveyors are bent models equipped with steel wire mesh belts. Low end of conveyor can be adjusted from 20 inches down to 8 inches above floor. Height of upper end ranges from 32 to 72 inches depending upon length of conveyor. Incline is 30 degrees from flat. Standard conveyor sizes are 60, 90, and 120 inches long with 8, 12, 16 and 20-inch wide belts giving 6, 9, 13 and 17-inch wide carring cleats. Flat end is available in 18, 24, and 30-inch lengths. Belt and side guides are replaceable. Variety of steel belt weaves and cleats are available. **Campbell Machines Co.,** 18634 Fitzpatrick, Detroit 27, Mich.

Circle No. **15** *on Reply Card*



INFRARED OVEN

Infrared paint drying system for automobile and truck bodies uses tubular quartz lamps with special polished aluminum reflectors which eliminate dead spots and give 100 per cent coverage. Mounted in special ceramic heat insulators to protect electrical connections, 1000 w lamps with a life over 5000 hours have individual low or high heat controls for localized drying. Unit consists of two vertical lamp banks and a horizontal lamp bank for drying tops, hoods and decks. All are suspended from overhead tram which traverses length of vehicle to be dried. Vertical banks may be adjusted for width and horizontal banks may be adjusted for height. By adjustments of banks in relationship to work, maximum heat efficiency is attained, thus reducing drying time. Standard car size has 12 kw consumption and truck size has 16 kw; both operate on 220v. **M & E Mfg. Co.,** 2571 Winthrop, Indianapolis, Ind.

Circle No. **16** *on Reply Card*

Ask yourself–

"Can we afford not to know about

AUTOMATION?"

Are you sure automation doesn't fit into your industry's production picture . . . or that a competitor isn't readying a nasty, automated surprise for you right now?

Now's the time to let Barnes & Reinecke engineers evaluate automation methods in terms of your product, and your plant. If special assembly machines will cut costs or improve your product, we can design, build, and install them for you.

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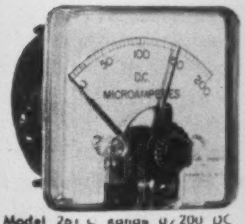


(Advertisement)

METER-RELAYS

For Sensitive and Accurate Control

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc.

Model 201 C Range 0/200 DC Microamperes Price $33.00

These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully.

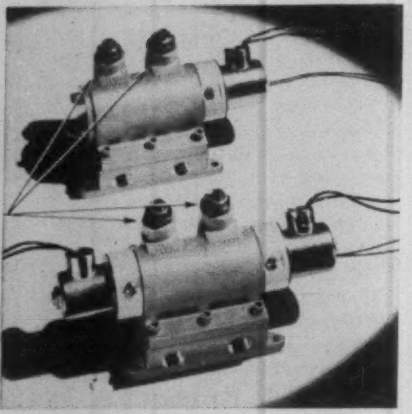
Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases). Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 27, Ohio.

Booths 425-426, Automation Show, Nov. 14-17, Chicago

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems



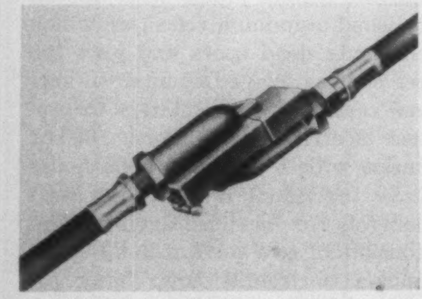
Pilot-Operated Control Valves

Recommended for machine applications where continuous operation and compact piping are needed, valves are available in double and single-solenoid, pilot-operated control models. Built-in flow controls (arrows) make them dual purpose valves. Two internal moving parts are single balance spool type stem that rides on aircraft type packing and solenoid pilot plunger with molded-in seats. Double-solenoid valve has two solenoid pilot plungers. Entire unit is completely sealed so that outside matter does not hinder internal operation. Double-solenoid model can be energized through a limit switch or a relay. Being dual solenoid, it is momentary electrical, contact type valve. Single-solenoid valve has spring return for electrical control and electrical contact must be maintained for duration of cycle. Solenoids are rated as continuous duty with power consumption of 10w maximum. Valves can be supplied for most ac and dc voltages and are available in following sizes: ¼, ⅜, ½, and ¾-inch with pipe tap size ports. Recommended pressures are from 20 to 150 psi air pressure for double solenoid and from 35 to 150 psi for single solenoid. **Airmatic Valve Inc.**, 7317 Associate Ave., Cleveland 9, O.

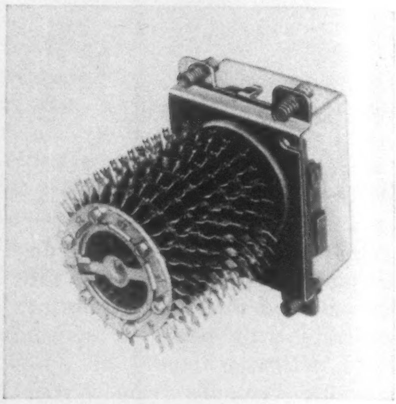
Circle No. **17** *on Reply Card*

Hose Coupler

Featuring free flow of fluid when connected and self sealing on break away, coupler is used in agricultural and industrial applications where unrestricted flow of fluid is desired and quick connect and break away hose coupling is needed. Coupling is available in ⅜ and ½-inch sizes. Free flow through coupler eliminates conventional coupler heating, clogging, pressure drop and power loss. It permits maximum operating efficiency when used in hydraulic, steam, gas, vacuum, air, cooling water, lubrication, irrigation or material handling lines. In operation, as barrels are hooked over slide lugs and coupler pushed together, barrels displace slides and barrel ports are brought into register or alignment, thus allowing free flow of fluid through coupler. Pulling coupler apart brings slides into position over ports. **Char-Lynn Co.**, 2855 26th Ave. S., Minneapolis 6, Minn.



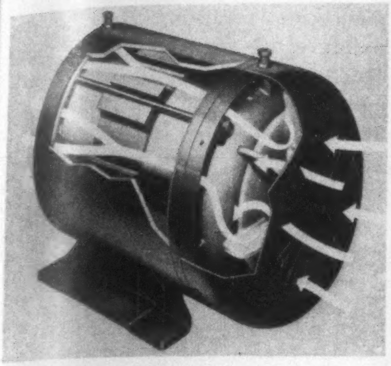
Circle No. **18** *on Reply Card*



Rotary Switch

Thirty-point, six-level rotary switch features precision construction. Contact bank assembly is built of molded ring layers, mounted directly on switch frame. Assembly is available with either two rows of contacts per level or one row of contacts and one common ring contact. Wiper assembly of switch is designed to assure reliability of contacts and to prolong life. Each wiper consists of two flat bifurcated springs, providing double contact surfaces at each level. Surfaces are in form of feet at end of each wiper spring. They make contact at heel and break with a snap action at toe. When not in operation, bank contact engages with wiper on clean surface between heel and toe, assuring good contact. Breaker effect reduces arcing, and flat wiping action keeps out dust. Plastic window for contact bank and transparent case for mechanism permit easy inspection. Switch is designed for use in automatic controls, scanning, coding, register storage, programming, sequence operation and pulsing. **North Electric Co.**, Galion, O.

Circle No. **19** *on Reply Card*



Ventilated Motors

Design of new motors utilizes NEMA-rerated frame sizes. Instead of conventional smooth outer surface, new stator design has wide ventilation slots in outer periphery. Dividing fins, fitted against steel frame, provide air passages for free movement of fan-driven air. Efficient heat dissipation is achieved by greater contact between circulated air and stator core, the main source of motor heat. Flow of cooling air is supplied by aluminum fan; rotor fans create further air turbulence around windings. Bearings are fully enclosed and protected against entrance of dust from both inside and outside of motor. Among features of motors are shock resistant steel frame, rigid cast iron end plates, precision punched stator laminations, mylar-film slot insulation, nonslip phase insulation at both ends of winding, heavy vinyl acetyl wire insulation, high stability copper clad rotor, double-shielded bearings, protective inner bearing cap, removable outer bearing cap and fully accessible, diagonally split conduit box. **Howell Electric Motors Co.,** Howell, Mich.

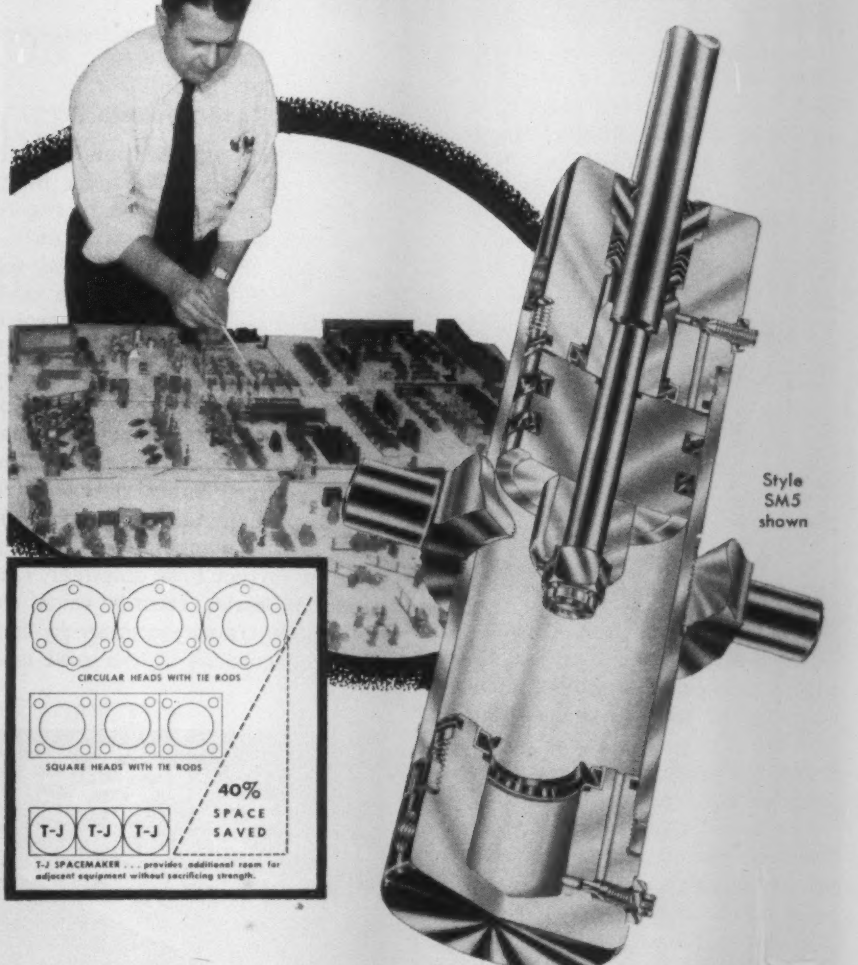
Circle No. 20 on Reply Card

Two-Coil Magnetic Pulley

New design of electromagnetic pulley features two-coil construction. Unit is designed to remove tramp iron on conveyor operations. Two-coil design produces an effective flux pattern with a deep magnetic field at center of pulley. Pattern conforms to normal conveyor load conditions. Two-coil pulley of smaller diameter than three-coil unit can maintain same efficiency in tramp iron protection in many applications. and at the

Automate for top performance with...

T-J Spacemaker CYLINDERS


Style
SM5
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CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
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40%
SPACE
SAVED
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

- The Only Cylinders with all the Extras as Standard
- OIL pressure to 750—AIR to 200 P.S.I.
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OFF SHELF DELIVERY

More and more of industry's automation problems today—solved with T-J Spacemaker Cylinders! New compact design and many more plus features for a new high in efficient cylinder performance and dependability. Wide range of styles, capacities . . . to help you *save labor, reduce costs* on all kinds of push-pull-lift jobs. Send for bulletin SM-155-1. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

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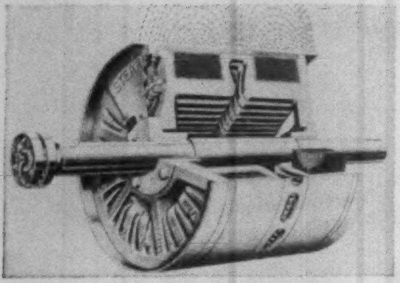
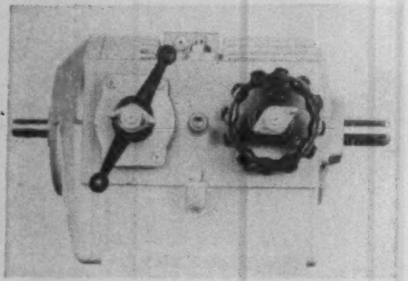


same time reduce equipment and power costs. Two-coil construction is available in variety of widths and diameters ranging from 12 to 60 inches. **Stearns Magnetic Inc.,** Milwaukee 46, Wis.

Circle No. 21 on Reply Card



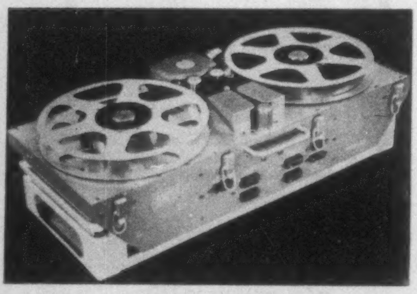
Hydraulic Transmission

Self-contained unit consists of driven oil pump and output oil motor. Rotating elements are incorporated in one air-cooled housing which acts as six-quart oil reservoir. All working parts are self-lubricated from reservoir. Variable speed hydraulic transmission may be directly coupled to electric motor supplying constant speed input power or belt driven from side or top mounted motor, depending upon space limitation. Overload protection is provided by safety valves. Output speed of hydraulic transmission may be evenly regulated by controlling amount of oil displaced by pump, or by controlling amount of oil consumed by motor, or both. Output speed at constant torque may be regulated by stroking the pump; constant horsepower is achieved through stroking the motor. Changes of speed and direction of rotation may be accomplished during operation or while unit is not operating. Standard variable speed hydraulic transmission is supplied with hand controls for stroking pump and motor. Remote controls are available to meet specific needs. Unit is applicable to agitators, beaters, can and bottle making machinery, conveyors, dairy machinery, hoists, machine tools, machinery for glass industry, mixers, paper machinery, power saws, printing presses, starting mechanisms, strokers, test stands, textile machinery, welding machines, winches and wood working machines. **Gerotor May Corp.,** Maryland Ave. & Oliver St., Baltimore 3, Md.

Circle No. 22 on Reply Card

Magnetic Tape Recorders

Series of magnetic tape recorders is available in versions ranging from units designed to record two channels of information on ¼-inch tape to models intended for recording 28 tracks on 2-inch tape. Plug-in amplifiers permit recording on any channel of pulse width modulation data, high accuracy transient information by means of wide deviation frequency modulation or wide band direct data including mixed subcarriers. Various recording techniques can be used in any combination by plugging in correct type amplifier. One model in series records seven information tracks on tape ½-inch wide. It consists of five cable connected units which can be mounted in any configuration desired, limited only by length of cables. Units are: a tape transport mechanism, record electronics, electronics power supply, tape transport supply and remote control unit. Unit is single speed machine with user able to select any of four speeds by shifting belt and pulley drive system. Transports are available with speeds of 1⅞, 3¾, 7½ and 15 inches per second, or 3¾, 7½, 15 and 30 inches per second. Unless specified by user, machines are shipped with belts in 7½ inches per second position. Housi g providing space for seven plug n record amplifiers contains the ecord electronics. Two types of amplifiers are available. **Instrume tation Div., Ampex Corp.,** 934 harter St., Redwood City, Calif.



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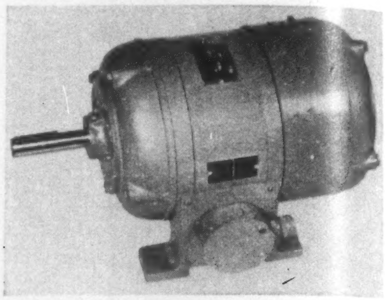


Motor and Mechanical Brake

Built into the frame of an electric motor and enclosed in the housing, motor brake is mechanical in action, eliminating solenoids and coils. Brake allows for smooth acceleration from standstill to full speed. Mechanical unit provides quick opening and avoids sudden stops. Tension springs can be adjusted for more rapid or slower stops. Brake assembly is provided with fans for temperature control. Brake motors can be installed in any position and are especially designed for work requiring frequent braking. **Cleveland Electric Motor Co.,** Dept. MB, 5213 Chester Ave., Cleveland 3, O.

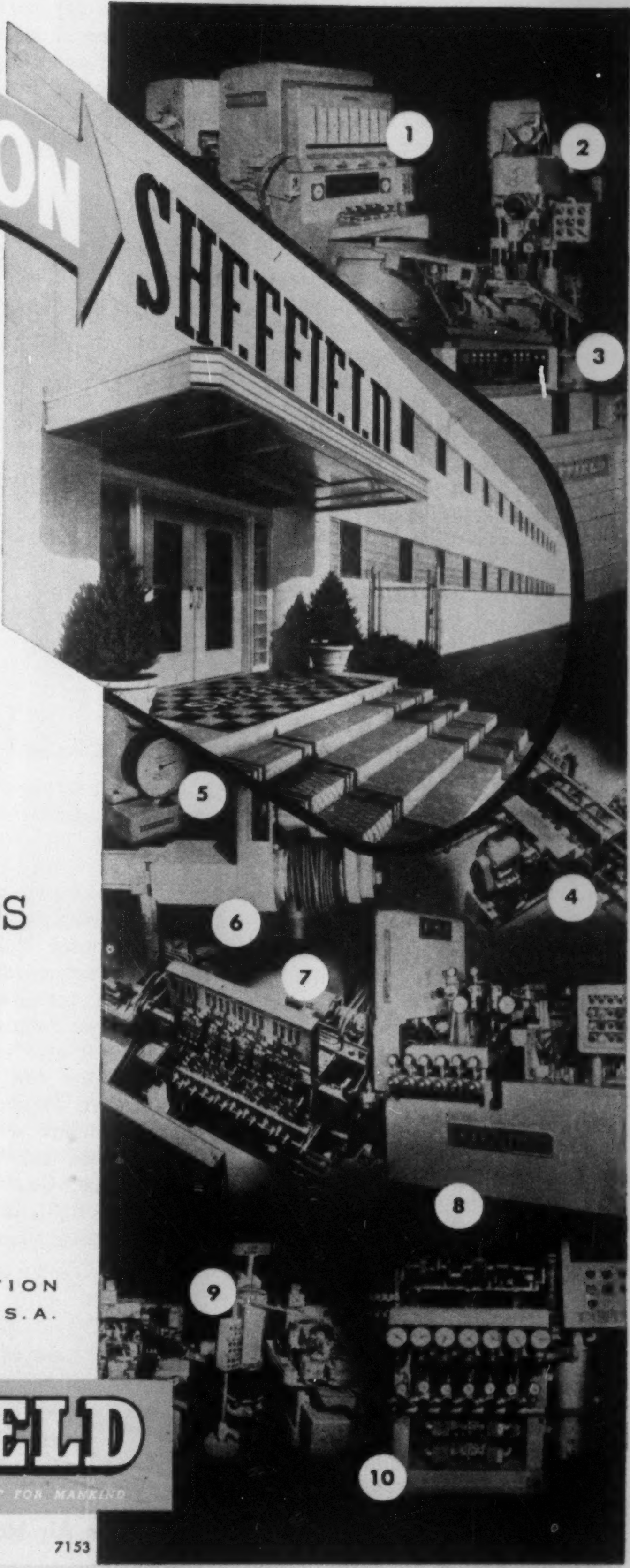
Circle No. 24 on Reply Card

Wire Stripper Generator

Designed for electrical and electronics industries, induction generator for wire stripping when combined with any conventional automatic wire stripping machine, will prebond ends of tinned stranded

AUTOMATION

· AND AUTOINSPECTION SYSTEMS, CIRCUITS AND CONTROLS HAVE BEEN OUR BUSINESS FOR MORE THAN A DECADE. IT WILL PAY YOU TO CHECK YOUR NEEDS AGAINST SHEFFIELD EXPERIENCE



WRITE DIV. 510 FOR BULLETIN NO. AU-1154

THE SHEFFIELD CORPORATION
DAYTON 1, OHIO, U.S.A.

MASTER CRAFTSMAN SHEFFIELD HEADQUARTERS

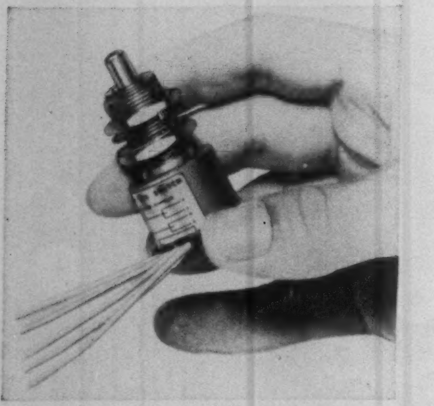
SHEFFIELD
MANUFACTURING AND MEASUREMENT FOR MANKIND

7153

1. Gaging cylinder bores for selective assembly
2. Controlled honing of gear blank bores
3. Automatic gage for 100% inspection of small arms ammunition
4. Connecting rod inspection
5. Controlling the grinding of ball bearing races
6. Post-process size control of bearing races
7. In-line inspection of automobile part
8. Controlling 12 grinding machines
9. Controlling bore size of pinion blanks
10. Automatic gaging of crankshaft main bearings

wire up to No. 26 gage. New system virtually eliminates process of hand twisting and dipping each lead prior to soldering operations. On solid or nontinned wires, application of unit loosens most plastic insulations in area to be stripped. Therefore, stripping is more easily accomplished and rejects due to nicks or scrapes are substantially reduced. Providing 1 kw of continuous duty output power, unit is available with graduated adjustable carriage, stepless power control and operates directly from any 110v power line. Unit can be instantly converted to use as standard induction heater for hermetic sealing, soldering or brazing when not in use as a wire stripper. **Induction Heating Corp.**, 181 Wythe Ave., Brooklyn 11, N. Y.

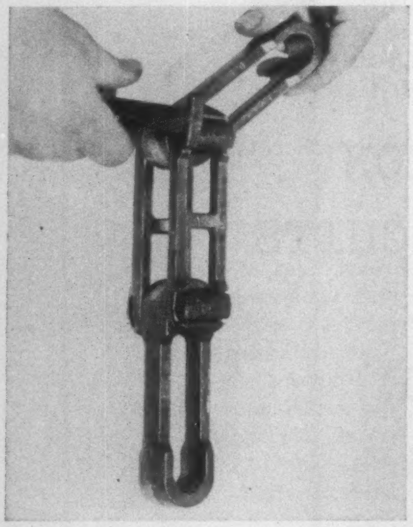
Circle No. 25 on Reply Card



Cylindrical Shaped Switch

Designed for use on exposed aircraft applications, cylindrical shaped switch is 1 inch in diameter and 2 inches high. Two single-pole double-throw switching units are sealed within can-shaped metal housing. Housing is evacuated and filled with inert gas under pressure, insuring constant operating characteristics regardless of atmospheric changes. Ice scraper at base of actuator scrapes off any mud or ice which might collect on plunger. Six 6-ft leads project at 90-degree angle from base of switch, so they may be run in any direction by rotation of switch on its axis. Switch is designed for bracket type or through-hole mounting. Plunger operates through threaded bushing which is 1 inch long. Assembly has lockwasher, key washer and two lock nuts drilled for safety wire, permitting approximately ⅞-inch adjustment of operating point. **Micro Switch, Div. Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

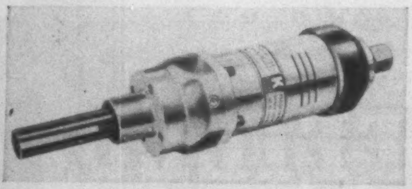
Circle No. 26 on Reply Card



Rivetless Chains

Designed for overhead conveyor use, series of drop forged rivetless chains are interchangeable with other makes. Chains have dry lubricant impregnated pins and machined bearing surfaces of both inner and outer links, eliminating need for surface lubrication. Dry lubrication permits operation in temperatures ranging from −30F to 800F. It also reduces the tendency of dirt and dust to create an abrasive action in the chain joints. Chains are available in three pitches and five sizes. **U.S. Engineering Co.**, 14561 Lesure Ave., Detroit 27, Mich.

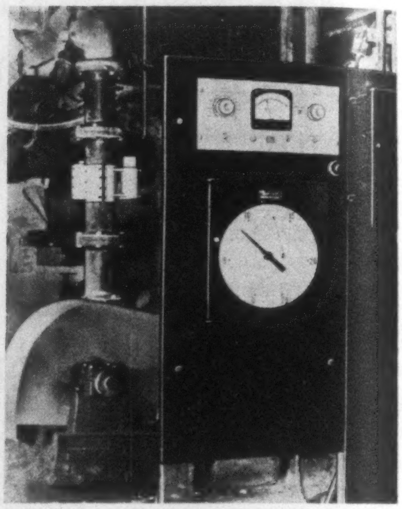
Circle No. 27 on Reply Card



Vane Type Air Motor

Available in five styles with center spindle gear case and in three styles with off-center spindle gear case, vane type air motor features compact construction and high power output. Developing 1 hp, center spindle style is less than 13 inches long and 3¼ inches diameter. Offset style is less than 15 inches long with maximum diameter less than 4½ inches. Designed for continuous duty, air motor provides quick starts and quick stops without overheating. It takes repeated or extended stalling without burning out and is nonsparking for safe use in hazardous locations. Speed is variable throughout range from zero to full speed; control is by means of air valve. **Keller Tool Div., Gardner-Denver**, Grand Haven, Mich.

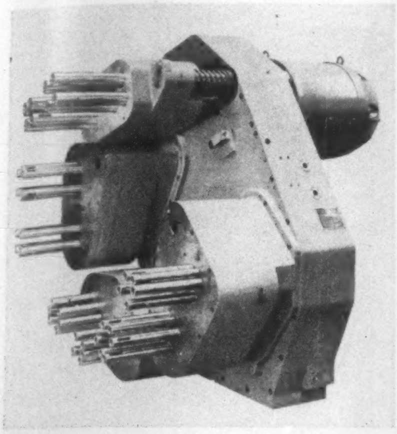
Circle No. 28 on Reply Card



Density Gages

The per cent by weight of solids or liquids in slurries can be measured and controlled through use of density gages which use Ohmart cells to measure radio-active absorption. Measuring components are located external to the pipe or vessel containing the slurry being measured. With a 10-inch sample of a slurry composed of water and a solids material of 2.0 specific gravity, measurements in the range of 0 to 40 per cent solids can be made with a precision of ±.3 per cent of solids. In the range of 40 to 80 per cent solids, measurement can be made to ±.2 per cent solids, and to ±.1 per cent when solids content is above 80 per cent. Illustration shows installation where a density gage is being used for the measurement of the solids content of an asbestos cement water slurry. Gages are also used for measurement of the per cent of solids in slurries of magnetite, clay, grinding compounds, coal and similar materials. **The Ohmart Corp.,** P. O. Box 67, Station B, Cincinnati 22, O.

Circle No. 29 on Reply Card



Lead Screw Tapping Head

New 41-spindle head consists of a master drive box which operates in horizontal position and is mounted and keyed on a hydraulic slide, an 11-spindle pot head for drilling, an 11-spindle pot head for chamfering, an 11-spindle pot head for reaming, and an eight-spindle individual lead screw pot head for tapping ½-inch-20 threads in steel forgings. Three pot heads for drilling, chamfering and reaming are driven through the master drive box by a 15 hp motor through a flexible coupling. Motor is mounted on hydraulic slide. Bushing plates are used for drilling, chamfering and reaming. Head operates in conjunction with five-station trunnion type fixture. Total height of head is 49 inches; total width is 42½ inches. In operation, after start cycle button is energized and drilling, chamfering and reaming spindles are rotating, hydraulic slide with head moves forward into its feeding stroke. Forward portion of lead screw spindle pot head comes to rest and locates on main trunnion fixture frame. Forward motion of hydraulic slide trips electrical contact switch which starts the tapping motor. While eight individual lead screw tapping spindles are moving forward and returning individually in tapping pot head, drilling, chamfering and reaming pot heads are performing their operations with for-

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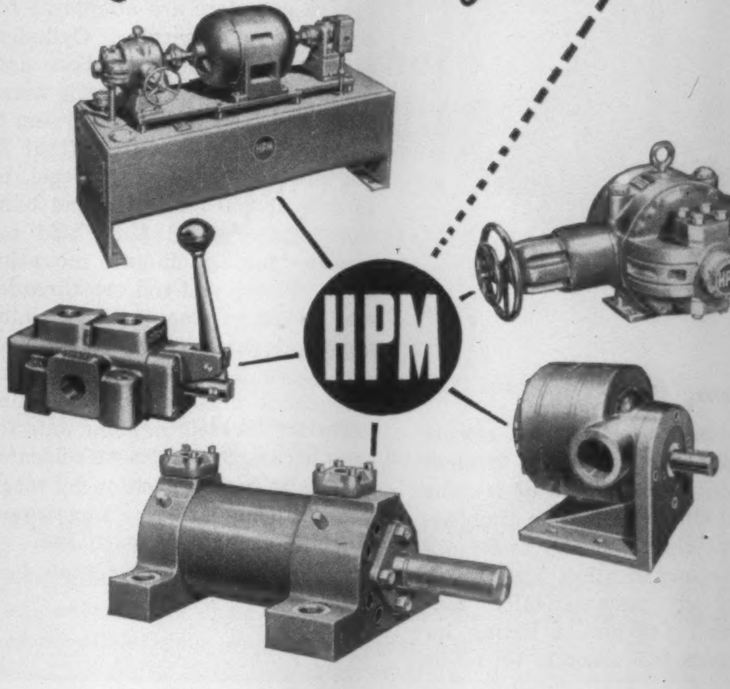
for savings



Buying component parts from one supplier can save a lot of time and trouble . . . less correspondence, a single responsibility, coordinated shipments are only a few of the many advantages. H-P-M's complete line of pumps, power units, valves, cylinders and system accessories can become your standard. This complete service plus H-P-M's experience background in the design and building of hydraulic systems can be a really major "assist" when needed. Write today for a complete catalog and get the facts on single source savings. Ask for Bulletin 1101.

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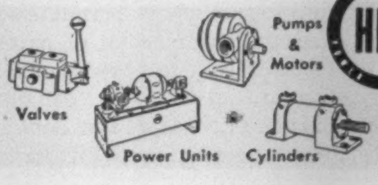
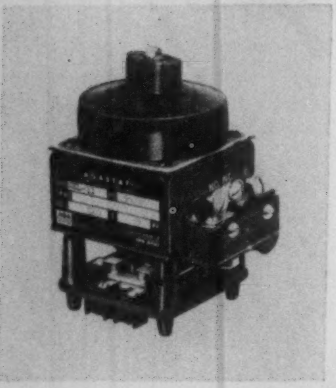
HYDRAULIC
POWER
DIVISION



ward motion of hydraulic slide. Individual lead screw tapping pot head completes its operation and the motor is stopped by means of zero speed plugging switch before main hydraulic slide starts its return stroke. **U. S. Drill Head Co.,** Dept. Y, 616 Burns St., Cincinnati 4, O.

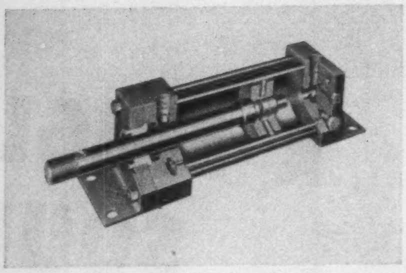
Circle No. **30** *on Reply Card*



Time Delay Relay

Electrical interlock in circuit which allows pushbutton control can be obtained by use of instant action auxiliary switch in time delay relay. Unit is designed for operation on energization. Time delay of relay is pneumatically controlled and provides a timing interval from 0.1 seconds to 10 or more minutes. Unit measures 2½ inches wide, 3⅜ inches deep and 4½ inches high. Affixed to front of relay is a normally closed double-throw limit switch. Contacts of switch are kept in open position by lever connecting auxiliary switch and core of relay. When relay coil is energized, core jumps up and contacts close instantly allowing interlock. Simultaneously, time delay period starts and continues to preadjusted time delay, at which time the main switch trips transferring contacts. In de-energization, auxiliary switch contacts change to open position and main contacts transfer. Time delay relay is available for all ac and dc voltages in single-pole, double-throw, double-break and double-pole, double-throw, single-break models. Relay is rated at 15 amp, 115v, 60 cycle ac. **AGA Div., Elastic Stop Nut Corp. of America,** Elizabeth, N. J.

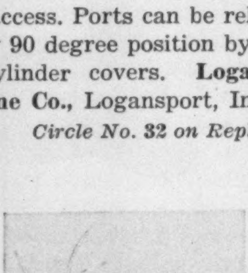
Circle No. **31** *on Reply Card*



Cylinder Line

Nonrotating, double-acting square cylinders are adaptable for either air or oil service. Cylinders are available in standard bore sizes from 1½ to 8 inches with maximum stroke as follows: air—up to 5 ft at 500 psi, up to 8 ft at 80 psi, oil—up to 3 ft at 500 psi, up to 5 ft at 250 psi. Rod and blind ends are of steel plate and are square for minimum mounting area. Piston and rod are threaded and locked in place with retaining nut for double security on all models above 3-inch bore. Cushion ball check and cushion adjusting valve are located on same side for easy access. Ports can be relocated to any 90 degree position by rotating cylinder covers. **Logansport Machine Co.,** Logansport, Ind.

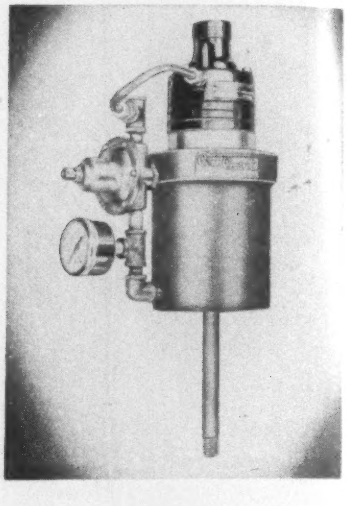
Circle No. **32** *on Reply Card*



Solenoid Actuated Valve

Series of four-way ¼-inch valves has same basic assembly which can be used as a spring return hand valve, a spring return foot valve, self-locking bench valve, spring return cam valve and a solenoid-actuated valve (illustrated). Feature of valve is interchangeability of actuating levers. Two large plugs permit easy cleaning and replacement of parts. Valves have built-in speed control. By regulating size of exhaust openings in valve, speed of double-acting cylinder in both directions can be controlled. By limiting return travel of plungers, exhaust openings are limited. **Mead Specialties Co.,** Dept. SV-46, 44 4 N. Knox Ave., Chicago 41, Ill.

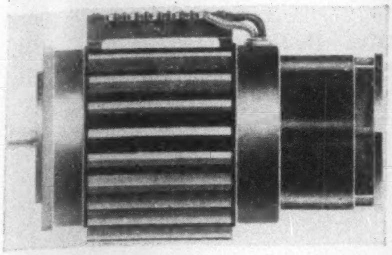
Circle No. **33** *on Reply Card*



Process Control Power Operator

Consisting of specially designed cylinder, piston with O ring seal, integral high capacity positioning device and cushion loading regulator, the pneumatically positioned power operators are available in variety of diameters and areas, travels and mounting arrangements, ranging from 2¼ to 10-inch bore with travels up to 10 inches in larger sizes. When travels are greater than 4 inches, or when characterization is required, cam and lever type of external positioning device is employed. Called Conomotors, units can develop thrusts as high as 5000 lb, yet are capable of holding thrust loads to within 0.002-inch of stem travel when positioned from automatic control instruments. Cylinder is cast from aluminum alloy. It is fitted with composition piston, sealed with graphite impregnated O-ring having frictional resistance of nearly zero. Built-in positioning device is small, compact and easily adjusted. It has large inlet and exhaust ports, providing fast speed of response with no loss of stability. Conomotor is responsive to instrument output changes of less than 0.2-inch of water and can be used with supply pressures as high as 100 psi. Fixed pneumatic balancing forces increase power, permit long stem travels with a minimum of space requirements and eliminate use of motor springs entirely. **Conoflow Corp.,** 2100 Arch St., Philadelphia 3, Pa.

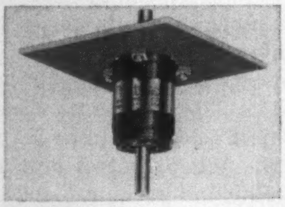
Circle No. **34** *on Reply Card*



Tachometer Generator

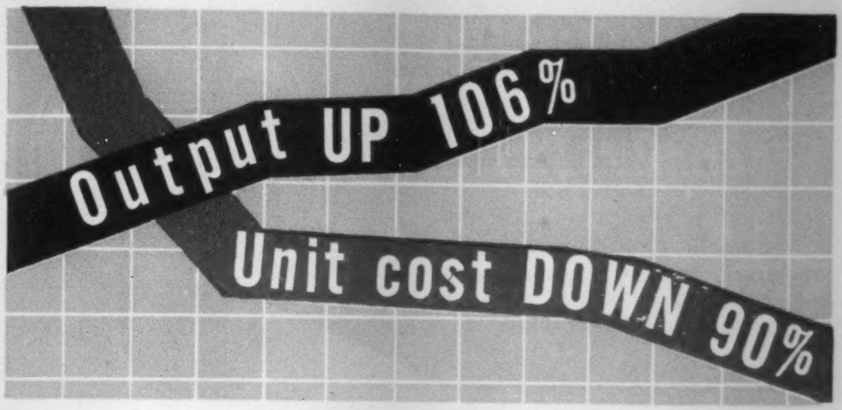
New 35w, two-phase ac servomotor-tachometer generator unit operates on 60 cycles. Addition to line of servomotors with tachometer generators includes units with motor ratings of 1, 5, and 10w. Instruments, including more powerful 35w unit, can be used to regulate speed of motor or to stabilize closed-loop circuits. With motor and tachometer mounted on single shaft, backlash is zero. Motor component is rated for continuous duty at rated output. It can be stalled continuously with one phase of the motor excited at rated voltage and frequency. Tachometer generator can be excited with its rated voltage and frequency. Suitable for use in automatic controllers, tachometer of new 35w unit can be readily adjusted after installation so that in-phase residual voltage of tachometer may be kept at essentially zero. Adjustments are made by loosening four screws and then adjusting core of generator. **Diehl Mfg. Co.,** Finderme Plant, Somerville, N. J.

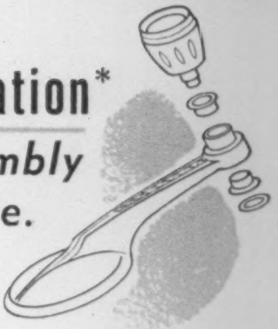
Circle No. **35** *on Reply Card*



Miniature Speed Reducers

New prefabricated speed reducers have servomount ends. Miniature units are available in 448 different ratios, from 1 to 1 up to





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AEL Packaged-Automation*

achieved for the assembly of this window handle.

Before AEL Automation:
24 workers + former methods = 2,900 units per hour @ 1¢ each

After AEL Automation:
4 workers + AEL = 6,000 units per hour @ 1/10¢ each

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Automation Engineering Laboratory *designs, engineers* and *builds* your equipment . . . is a single source of responsibility to handle the *entire* job of automating your production process. AEL will—

- **Make engineering study of the job to be done**
- **Submit firm proposal to supply automatic equipment at a fixed price, guaranteed to perform in accordance with specifications**
- ***Design* and *build* complete automated unit or system**
- **Run test for client before delivery**

WILL AUTOMATION WORK FOR YOU?

If your product requires fabrication, assembly, packaging or feeding—if you have a repetitive operation that takes the full time of one or more workers—*AEL Packaged-Automation* can very likely boost your output, cut your production cost.

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AUTOMATION ENGINEERING LABORATORY
Greenwich 8-2300
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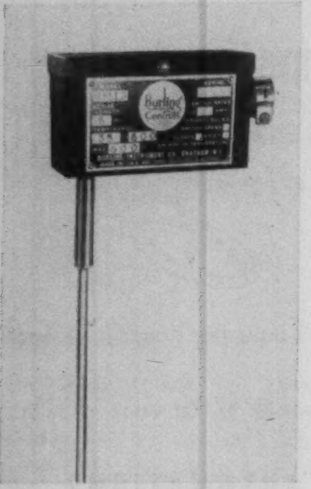
531,441 to 1. Speed reducers may be either clamp mounted by using a groove and a clamp assembly, or end mounted, using four tapped mounting holes. Reducers have a 1/40-hp rating, with hobbed spur gears hardened to give smooth operation. These reducers offer design possibilities in flow controls, computers, timers, oscillographs and in low power devices. **Metron Instrument Co.,** 432 Lincoln St., Denver 3, Colo.

Circle No. 36 on Reply Card



Expansion Thermostat

Designed for use in laboratory baths and ovens, differential expansion thermostat has a range of 35 to 600F and can be subjected to excessive high or low temperatures outside of range without damage. It is capable of controlling temperatures to within ±1/2F in liquids and ±1F in air. Stainless steel sensing element measures ¼-inch OD by 6 inches long. Control is obtained by differential expansion of rod within tube, actuating snap action switch rated at 15 amp, 125 to 250v ac. Lever is used to multiply expansion of tube and thereby increase sensitivity, decrease size, and protect switch. Switches with other ratings or with manual reset button are available and are interchangeable with standard switches. Unit is designed for local mounting and may be furnished with flange or threaded fittings. Thermostat case measures 1⅜ by 2¼ by 3¾ inches. **Burling Instrument Co.,** 16 River Rd., Chatham, N. J.

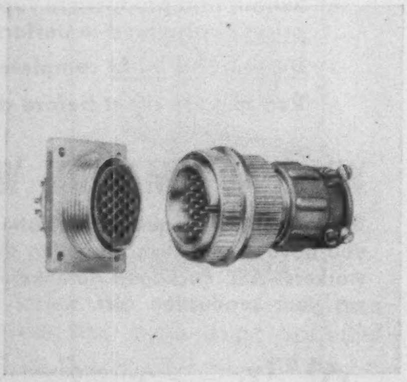
Circle No. 37 on Reply Card

GITS BROS
AIRLINER

Air Line Lubricator

Oil is atomized in a chamber remote from the air line by new air line lubricator. Only oil mist is injected into the air stream. Oil is metered in particles almost as light as air itself. Mist provides constant lubrication throughout the operational period. Unit is monitored through the large, transparent dome of the mist generator. Lubrication of air volumes ranging from ¾-cu ft up to capacity of the airline regardless of cycle frequency is possible with the lubricator. Unit is adaptable to right or left hand mounting without modification. **Gits Bros. Mfg. Co.,** 1866 S. Kilbourn Ave., Chicago 23, Ill.

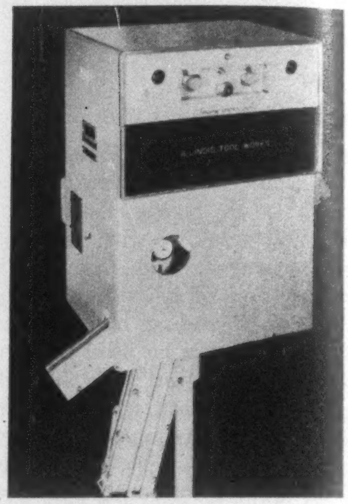
Circle No. 38 on Reply Card



Miniature Connectors

Designed for applications on missiles, aircraft electronics and miniature portable electronic gear, miniature connectors feature one piece molded inserts to prevent moisture traps and electrical breakdown. Aluminum shells are finished to meet military requirements for salt spray test resistance. Inserts are permanently swaged into the shell to form a single cartridge unit. Floating contacts assure self-alignment of each contact and reduce engagement and disengagement forces to a minimum. Two shell sizes accommodate 3, 4, 5 contacts or 15, 19, 27, 31 contacts. **Electronic Sales Div., DeJUR-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N. Y.

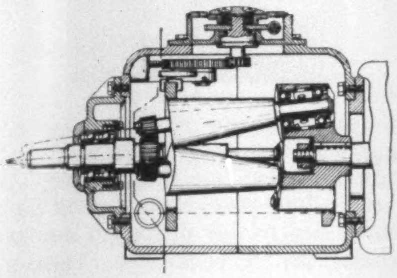
Circle No. 39 on Reply Card



Gear Size Control Unit

Used in high production gear manufacturing, gear size control unit rejects gears that are undersize and oversize. It accommodates gears up to 3 inch-diameter in various pitches and face widths, and can be set to any tolerance from 0.0001 to as coarse as desired. Rejected gears are delivered out of one chute and passed gears are delivered through another chute. Unit has an integral, continuously operating computer that shuts off production when percentage of rejects reaches a predetermined level, or after a certain number of continuous rejects. Percentage-of-rejects selector can be set at any one of 30 levels, from 1 to 33⅓ per cent. Consecutive reject selector can be set from 1 to 10. When control unit shuts off production machine, red light goes on, indicating that corrective adjustment is necessary. One signal light indicates percentage-of-rejects level has been reached; another light shows that consecutive reject point has been reached. Computation is continuous. Each time a good gear is passed, continuous reject counter returns to zero. With each gear passed or rejected, percentage is recomputed. **Illinois Tool Works,** 2501 N. Keeler Ave., Chicago, Ill.

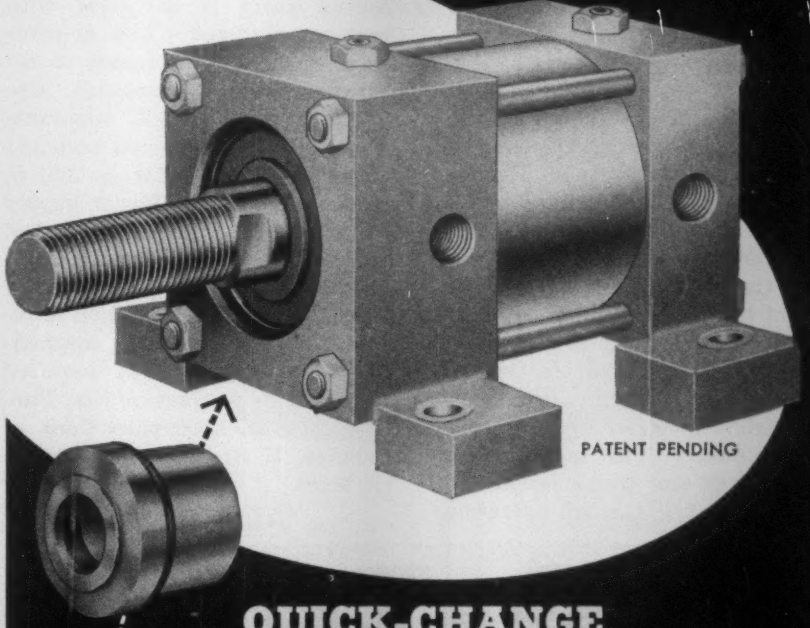
Circle No. **40** *on Reply Card*



Variable Speed Transmission

Variable speed transmission is designed to provide small but accurate speed adjustment. Roller carrier in the speed corrector is driven by the motor, or input shaft if a transmission without motor is used. Three tapered rollers are supported in the carrier and are inclined at an angle equal to their taper so that the outer edge of the rollers is parallel to the central axis of the transmission. A control ring encircles the three rollers and traction pressure is developed between the rollers and the ring through the centrifugal force of the rollers as the carrier is rotated at motor speed. Bevel pinions fixed to the large end of the rollers engage a sun gear mounted on the output shaft. Speed of the output shaft is equal to the speed of the input shaft plus a variable speed determined by the gear ratio and the diameter of the roller at which the encircling control rings make contact. The ring position is set and maintained with accuracy through the control gear linkage. For most applications, the transmission is equipped with built-in gear reduction, single or two-stage helical spur or worm gear reducer, so that the range of output speed is both above and below the input speed. For applications where the input speed is low or variable, the transmission is equipped with a spring loading device which provides the traction loading between rollers and the encircling control ring. **Graham Transmissions Inc.,** Menomonee Falls, Wis.

Circle No. **41** *on Reply Card*



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QUICK-CHANGE PACKING CARTRIDGE Cuts Downtime

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- Designed for 200 PSI
- Rolled steel end plates
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* S-P Automation Cylinders were designed expressly for a large automobile manufacturer. They are thoroughly proven for automation and general heavy-duty applications. Prompt deliveries. Send for Catalog 109. For S-P standard Air Cylinders, request Catalog 102. The S-P Manufacturing Corp., 12415 Euclid Ave., Cleveland 6, Ohio.

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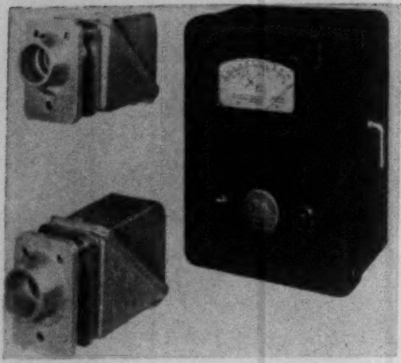
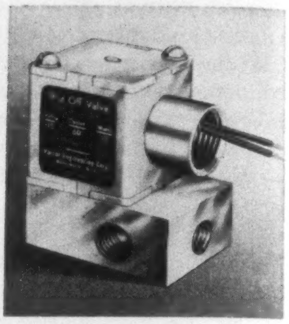
COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES AND ACCESSORIES



Photoelectric Control Unit

Designed for use in textile, paper, chemical, beer, petroleum and plastics industries, photoelectric control unit helps eliminate smoke nuisance in industrial smoke stacks and ventilating ducts, monitors light transmission or optical density of liquids in chemical processing lines, and regulates turbidity in water and sewage treatments. Unit consists of light source, photoelectric scanner and control unit with a meter. Two meter scales indicate per cent transmission and optical density. Control operation is provided at any light transmission value from 0 to 90 per cent. Green light indicates normal condition, red light indicates excess smoke or density condition. For smoke density control the unit automatically turns off blowers, closes dampers and operates multiple warning devices. When used in continuous process operations the densitometer will indicate and control composition of fluids by monitoring their turbidity or variations. Control relay is energized with light on phototube, and de-energized when light decreases to selected per cent transmission. Operating range is 20 ft maximum between light source and scanner; scanner can be as far as 200 ft from control unit. Power supply is 115 to 230v, 50 to 60 cycles. Response time is 3.5 seconds maximum when 90 per cent or greater change in light transmission is required to actuate relay; approximately 1 second when required change is 10 per cent or less. **Photoswitch Div., Electronics Corp. of America,** 77 Broadway, Cambridge 42, Mass.

Circle No. **42** *on Reply Card*



Solenoid Valve

New four-way solenoid valve features dependable operation despite contaminating conditions. Valve is designed with one sealing surface that is self-cleaning. Due to a constant wiping action, contamination cannot interfere with its normal operation. Single coil unit is designed for use with air, oils and other media. Available with conduit or standard fittings, 1/4-inch NPT pipe connections, 115v ac continuous duty, valve has 10w power consumption. **Valcor Engineering Corp.,** Carnegie Ave., Kenilworth, N. J.

Circle No. **43** *on Reply Card*

"PIG-TAILORING"

. . . . a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.

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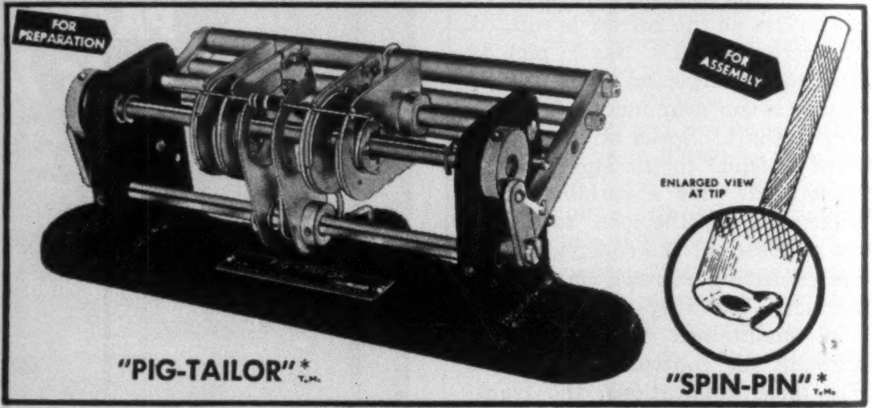

The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

* PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. AP-10

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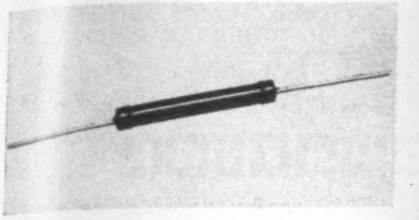
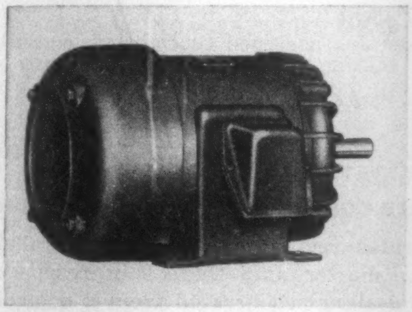


Precision Resistors

Deposited carbon precision resistors are used where accurately matched pairs, low inductance, and predictable change characteristics are needed. Pure crystalline carbon is deposited on a ceramic insulator by a patented method of thermal decomposition of a hydrocarbon. High resistance values are attained by spiral cutting through the coating. Resistance element is protected either by multiple layers of insulating, moisture resistant varnishes separately baked on, or by hermetic sealing in a steatite shell. Resistors meet standard tolerances of ±5 per cent. **Campbell Industries Inc.,** 3806 St. Elmo Station, Chattanooga 9, Tenn.

Circle No. 44 on Reply Card



Fan Cooled Motor

Available in fractional and integral hp ratings from ½ to 100 hp for both single phase and polyphase operation, fan cooled motor is designed for use in dirty, dusty, fume and mist-laden atmospheres. Motor features aluminum rotor, ventilating fan designed to provide operation in either direction without having to change fan, six-layer insulation for stator windings, and mechanical modifications which provide availability of brackets for bolting motor to machine. **Century Electric Co.,** 1806 Pine St., St. Louis, Mo.

Circle No. 45 on Reply Card

transistor and
digital computer techniques

APPLIED TO THE DESIGN, DEVELOPMENT
AND APPLICATION OF

AUTOMATIC RADAR DATA PROCESSING,
TRANSMISSION AND CORRELATION
IN LARGE GROUND NETWORKS

Engineers
&
Physicists

Digital computers similar to successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

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CLAMP-TYPE AIR CYLINDERS

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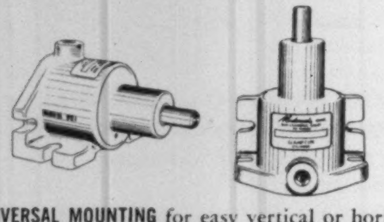

UNIVERSAL MOUNTING for easy vertical or horizontal installation.

SLOTTED MOUNTING HOLES save installation, relocation time.

SPRING-RETURN TYPE CYLINDER operates from simple 3-way valve (MODERNAIR CRV or BV series recommended). Has 1/8" NPT port.

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Price (f.o.b. factory)

Bore Size	1" Stroke	2" Stroke
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2"	16.00	19.00
3"	23.50	26.50

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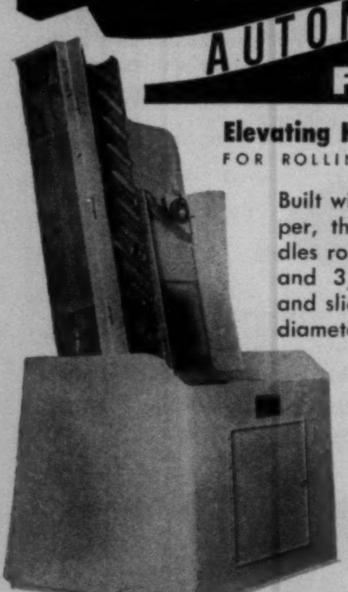

Elevating Hopper Feed No. 2500
FOR ROLLING OR SLIDING PARTS

Built with a large, 6 cu. ft. hopper, this Elevating Feeder handles rolling parts 5" in diameter and 3/16" to 1½" in length, and sliding parts 3/16" to 2" in diameter and up to 6" long.

The Unit features low loading point and variable high delivery point. Delivery rate is also variable. Take-off from the conveyor may be either right or left hand or both.

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AUTOMATION

patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Controls

MAGNETIC MEMORY UNIT FOR MOTOR CONTROL SYSTEM

Intelligence signals for a control system are recorded on a rotatable magnetic drum. Patent 2,712,624 by Clare L. Beattie, assigned to General Electric Co.

CONTROL APPARATUS FOR AND METHOD OF CONTINUOUS CASTING

Pouring of molten metal into an open-ended casting mold is controlled to produce a preset standard rate of pour. Patent 2,709,284 by Sidley O. Evans and Isaac Harter Jr., assigned to Babcock & Wilcox Co.

◆ ◆ ◆

Data Processing

TAPE CONTROLLED COLUMN BY COLUMN CARD PUNCH

Machine perforates rectangular cards in parallel columns across shorter axis thereof in response to punch control signals generated from a control tape. Patent 2,711,794 by Ioino Ghertman, assigned to International Business Machines Corp.

ARRANGEMENT FOR ANALYSIS AND COMPARISON OF RECORDINGS

Device compares two numbers represented on two tabulating cards by markings in successive columns. Patent 2,712,898 by Knut A. Knutsen, assigned to Compagnie Des Machines Bull, Paris, France.

◆ ◆ ◆

Handling

SELECTIVE FLUID METERING SYSTEM

Material dispensing apparatus includes material discharging means, means for establishing electrical signals proportional to quantities discharged, and key-operated switches. Patent 2,712,885 by John T. Winship, assigned to Standard Oil Co.

MECHANICAL LOADER AND UNLOADER FOR PRODUCTION MACHINES

Mechanically operated pivoting device loads and unloads production machines. Patent 2,711,817 by Llewellyn A. Hautau and Charles F. Hautau.

◆ ◆ ◆

Machines

APPARATUS FOR OILING METAL STRIP

Oil mist generated in atomizing chamber has oversize particles eliminated by movement through baffles and is charged to high potential with respect to the strip being oiled. Patent 2,710,589 by Ray C. Brunner, assigned to Jones & Laughlin Steel Corp.

MACHINE FOR CUTTING CONTINUOUS MATERIAL INTO A SUCCESSION OF PRE-SELECTED LENGTHS

Solenoid operated clutch drives a roller feeding continuous material. Limit switches control feeding and cutting. Patent 2,713,904 by Irving Ostuw and Hiram D. Dillard.

◆ ◆ ◆

Measuring

PNEUMATIC DIFFERENTIAL APPARATUS

Apparatus simultaneously gages several dimensions of an article. Air discharge through orifices positions diaphragms controlling electrical contacts. Patent 2,707,389 by Andre L. A. Frotier, assigned to Etavex S. A., Geneva, Switzerland.

PNEUMATIC CONCENTRICITY GAGE

Air jet on a gaging spindle is controlled by a work-contacting finger. Housing for the spindle is centered with respect to the part by additional air jets. Patent 2,712,181 by Raymond A. Mahlmeister, assigned to the Sheffield Corp.

◆ ◆ ◆

Packaging

HEAT SEALING APPARATUS

Conveyor carries packages wrapped in thermoplastic heat-sealable film across top of table which has a heated plate and a cooled plate in its surface. Patent 2,707,018 by Duncan G. Bolton, assigned to E. I. du Pont de Nemours & Co.

◆ ◆ ◆

Testing

AUTOMATIC EGG CANDLER

Eggs passing between a strong yellow light source and a detector are switched to a different path if they absorb more than a preset proportion of the light. Patent 2,708,515 by George N. Bliss.

AIR VALVE COMESTIBLE SORTING APPARATUS

Device incorporates an electromagnetically operated valve to control air flow through strategically placed nozzles. Patent 2,713,409 by Harold W. Bartlett, assigned to California Packing Corp.

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5

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■ EFFICIENCY
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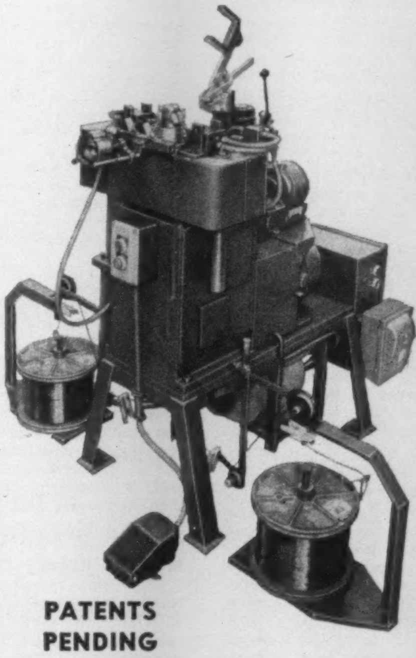
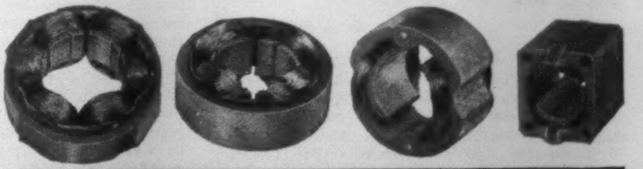
WINDS UP TO 150 STATORS PER HOUR



PATENTS PENDING

- Winds 2, 4, 6 and 8-pole stators—all poles on any unit being wound simultaneously.
- Adaptable for index winding series-wound stators or stators for split-phase and multiple speed motors thereby eliminating the interpole connections.
- Standard model winds wire from 19-gauge to 36-gauge at speeds ranging from 300 to 600 turns per minute. Heavy-duty model winds wire from 14-gauge to 18-gauge at speeds ranging from 150 to 350 turns per minute.
- Automatic controls permit selection of any number of turns from 1 to 2000. Cycle is automatically repetitive.
- Takes stacking heights to 3" maximum; diameters to 6" o.d.
- Automatic lead cutoff serves as lead anchor in starting next stator. One operator can handle multiple machines.
- Write for complete data or, if convenient, arrange to call at our plant where a machine is always available for demonstration.



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new CATALOGS AND LITERATURE

Aerial Photography Handbook

Chicago Aerial Industries—"Advancing Horizons" is the title of 28-page handbook on aerial photography. Problems of coordination, synchronization and computation incurred in aerial photography, precise optical sighting, and image motion compensation are illustrated with photographs and sketches, and their solutions given. Continuous printer, strip camera, image motion compensation magazine, stereo viewer, stereo projector, special camera and scanner system are discussed and pictured. Separate sections are devoted to company facilities for research and engineering, manufacturing, and quality control.

Circle No. 46 on Reply Card

Automation Conveyor Belts

B. F. Goodrich Co.—Use of conveyor belts on automation lines is the subject of two-page data sheet. Lightweight automation belts designed by company feature new fabric, uniform tension, compact edge construction, and skim coats between each ply. Four types of conveyor belts are covered: Tan Koroseal type which handles greasy or acid materials; Caripack type which carries oily parts; High-seal type which resists moisture, acids, most greases, fats and alkalies; and Economy Type for use where oil resistance is not required. Photographs of conveyors and splicing procedure are included.

Circle No. 47 on Reply Card

Mechanical Brake-Motor

Cleveland Electric Motor Co. — Two-page data sheet announces new mechanical brake-motor which is well suited for machine tool, bridge or trolley applications. Motor does not require use of solenoids, coils and special control equipment. Photograph illustrates brake-motor. Other units in company line mentioned are fractional hp polyphase squirrel cage motors, integral hp squirrel cage motors, and wound rotor motors.

Circle No. 48 on Reply Card

Photoelectric Controls

Photoswitch Div., Electronics Corp. of America — Automation through photoelectric control is the subject of 20-page catalog. Among jobs which can be accomplished through photoelectric control are order filling, traffic control, sorting, door control, adjusting, precision filling, counting, smoke detection, cutting, inspection and temperature control. Two-page chart indicates method of selecting controls for particular jobs. Photographs and specification information on multipurpose controls, conveyor controls, control sets for long range operation, high-speed counting, inspection or sorting by reflected light, registration control, and high-temperature measurement and control are included. Accessories such as extended lens system, infrared filter, etc. are illustrated.

Circle No. 49 on Reply Card

Engineered Magnets

Indiana Steel Products Co.—Subjects covered in July 1955 issue of "Applied Magnetics" include considerations in design of magnetic synchronous drives, characteristics of permanent magnet material called Cunife which is ductile, malleable and machinable after final heat treatment, and cigarette quality control application which utilizes a permanent magnet. Ten-page house organ contains permanent magnet drive evaluation table, curves, and sketches illustrating article on synchronous drives, and photographs of magnets and quality control equipment.

Circle No. 50 on Reply Card

Industrial Systems Engineering

Berkeley Div., Beckman Instruments Inc.—Industrial systems engineering for data reduction, industrial control, information processing, and special instrumentation are discussed in 12-page brochure. Case histories illustrate systems engineering solutions to problems such as a steel mill count control, gas pipeline data transmission, jet engine tachometer controller, wind tunnel computer controller, digital computer input device, etc. In each case history, situation, problem and solution are explained, with sketches used to show solution and with advantages of particular solution outlined. Photographs illustrate company facilities.

Circle No. 51 on Reply Card

Prelubricated Bearings

Reliance Electric & Engineering Co.—Four-page brochure, "New Automatic Grease Monkey," describes prelubricated bearing design used on company's ac and dc motors. Design features new metering plate which automatically regulates grease flow to bearings and provides pressure relief against over greasing. Plate continuously lubricates bearing and is independent of plant lubrication schedules. Cutaway photograph illustrates double shielded bearing with metering plate.

Circle No. 52 on Reply Card

Multiple Rotary Slitting Lines Book

Yoder Co.—Comprehensive, 76-page book is revised edition on multiple rotary slitters, uncoilers, recoilers, scrap choppers and coil cars. Book contains information on choice and operation of slitting lines; analysis of slitting cycle with time studies for different speeds, coil sizes and weights; operating cost and savings possible by use of equipment for loading and unloading coils after slitting and banding; slitting narrow strands; protecting highly finished strip in slitting; and relative advantages of small versus large slitters, and small versus large coils. Book is divided into two parts. Part I discusses basic information on design, selection and operation of slitters; part II contains specifications, capacity tables and general data on Yoder machines. Numerous application photographs are used throughout the book. Subject index is included to assist reader in locating desired subject matter.

Circle No. 53 on Reply Card

Oil-Less Air Compressors

Bell & Gossett Co.—Piston type motor-compressor units which deliver oil-free air are the subject of 12-page brochure. Compressors feature precision balance and need no lubrication or oil separators. Bulletin discusses their construction and gives specifications. Units are available for 35, 75 and 175 lb pressures with displacements ranging from 1.43 to 6.57 cfm. Dry vacuum pumps rated maximum 27.5 inches referred to a 30-inch barometer are listed for displacements from 2.7 to 6.57 cfm. Information is also included on spray guns, tanks, and carts for use with company units. Numerous photographs and sketches are used to illustrate bulletin.

Circle No. 54 on Reply Card

Flexible Metal Hoses

Universal Metal Hose Co.—Reference manual discusses flexible metal hose products made in bronze, carbon steel, monel, nickel or stainless steel. Various types are available to compensate for conditions of varied pressure, elevated temperature, motion and vibration for wide range of conveyance problems. Use and application data are included in manual.

Circle No. 55 on Reply Card

Measurement and Control System

Weston Electrical Instrument Corp.—System of direct current amplification for low level measurement and control is discussed in 12-page brochure. Technical information and application data on a basic dc amplifying unit is given, along with material on multi-range dc amplifiers, sensitizing amplifiers, integrating fluxmeters, limit and knife edge control units and product resolvers. Photographs of various models are included.

Circle No. 56 on Reply Card

Air Filters and Lubricators

Master Pneumatic Inc.—New developments in line of air filters and lubricators are covered in 20-page brochure. Changes in principles of air filtration now used in industry are discussed and illustrated. Unit which automatically empties filters and other accumulators of trapped liquids and sludges is illustrated. Porous bronze filter elements and applications to air, water, gas and oil filtration are described. Oil feed lubricators which adjust to varying air flow are also discussed. Filter and lubricator installation and maintenance are covered. Dimensions sheet, parts list and photographs are included in brochure.

Circle No. 57 on Reply Card

Round Steel Strapping Machine

Gerrard Steel Strapping Div., U. S. Steel Corp. — Four-page brochure contains numerous application photographs of round steel, semiautomatic strapping machine. Machine is designed for reinforcement, closure and unitizing of corrugated and fiber containers, light box shooks, dimension stock, light wooden cases, newspapers and magazines up to 75 lb. Machine will make up to 12 to 15 ties per minute.

Circle No. 58 on Reply Card

Roller Conveyor Catalog

E. W. Buschman Co.—Medium and heavy duty roller conveyors are discussed in twenty-page catalog. Specifications on complete line of items describe various types, with capacities of rollers and bearings. Detailed cutaway views show dustproof and grease packed bearings which are metal sealed, as well as integral and plain ball bearings. Rounded ends, turned-in ends, swaged and reamed straight ends of rollers are shown in angle frames, formed or structural channel frames, with charts giving roller and frame capacities. Heavy duty mobile unit for straight sections of roller conveyor is illustrated. Also shown are roller curves, spur sections, sliding switches, converging section, vertical lift and horizontal gate sections in permanent and portable types. Installation views illustrate roller conveyors combined with overhead cable, live roller and vertical reciprocating lift, belt and other types of conveyors.

Circle No. 59 on Reply Card

Magnetic Tools Catalog

Apex Machine & Tool Co.—Magnetic nut running and screwdriving tools, with permanent magnets providing the magnetic force to hold nuts and screws in driving position, are described in new catalog. Included among nut running tools are magnetic sockets for use on sheet metal screws, bolt clearance type magnetic sockets, reversible magnetic sockets and magnetic sockets for straight and angle grease fittings. Screwdriving tools include line of magnetic bit holders, service drive bit holders and hand drivers, along with range of insert bits to be used with holders.

Circle No. 74 on Reply Card

Designing A Control System

CDC Control Services Inc.—Techniques used in solving a temperature-pressure control problem are discussed in "Automation Engineering Bulletin". Control system designed required high accuracy, resolution and frequency of response. Four-page bulletin includes reproductions of test data used to determine final valve and other component specifications. Photographs and schematic diagrams illustrate steps used in solution of problem.

Circle No. 75 on Reply Card

Overhead Handling and Automation

Whiting Corp. — Twelve-page brochure, "Planning the Crane for Its Use in Automation", discusses use of overhead materials handling in trend toward automation. Factors to consider in planning for use of the crane, definition of the crane and types of crane service, such as standby, intermittent industrial, regular industrial, continuous materials handling and steel mill cranes in the top running overhead models are covered. Gantry and underhung cranes and monorail systems are also discussed. Photographs illustrate applications of various models. Two unusual warehouse and foundry applications are described.

Circle No. 76 on Reply Card

Coolant Filters

Industrial Filtration Co. — Four models of Thompson grinders equipped with coolant filters are illustrated in four-page brochure. Thompson grinders which use wet grinding methods and recommended filter for each model are listed. Self-cleaning gravity filters remove solids from liquids that will flow, by gravity, through filter material. Filter then discharges solids into an outside container. Brochure discusses operation of filters, and indicates advantages of using filters on grinding machines.

Circle No. 77 on Reply Card

Snap Action Switches

Unimax Div., W. L. Maxson Corp.—Among types of switches discussed in 24-page catalog are high sensitivity, metal cased, immersion proof, general purpose, dc and subminiature models. Pictorial index assists reader in selection of right switch for any application. Catalog covers each switch type with photographs and detail drawings, illustrates types of actuators available, provides base and terminal data, physical dimensions, operating characteristics and electrical ratings.

Circle No. 78 on Reply Card

Precision and Commercial Gears

Technical Products Co. Inc.—Application of scientific knowledge of gear ratios, metals, stress and design to requirements of electronics field and atomic energy field, as well as to the electrical and mechanical industries is way in which company assists in solving gear problems. Six-page brochure includes discussion of research, development and design sections of company. Case history problem and its solution are discussed to illustrate services offered.

Circle No. 79 on Reply Card

Fittings for Instrumentation Lines

Parker Appliance Co.—Flareless type tube fittings designed for copper instrumentation lines are the subject of 12-page catalog. Materials and threads, connectors, union and union cross models, elbows, tees, reducer, nut, and ferrule are illustrated, with their specifications given in chart form. Instructions on assembly of knurled nut and expander insert for use with plastic tubing are also included.

Circle No. 80 on Reply Card

Valves and Valve Accessories

General Controls Co. — Comprehensive 54-page catalog discusses line of motor operated valves and valve accesories. Among types of valves covered are low pressure, gas, two-way, three-way, process and high speed models. Accessories discussed include inner valves, dust shields, packing glands, actuator housings, auxiliary switches, transformers and valve trims. Engineering data gives information on determination of valve body material, valve selection and flow factors. Illustrations of models in all types, specification data, flow charts and photographs are included.

Circle No. 81 on Reply Card

Silicon Junction Diodes

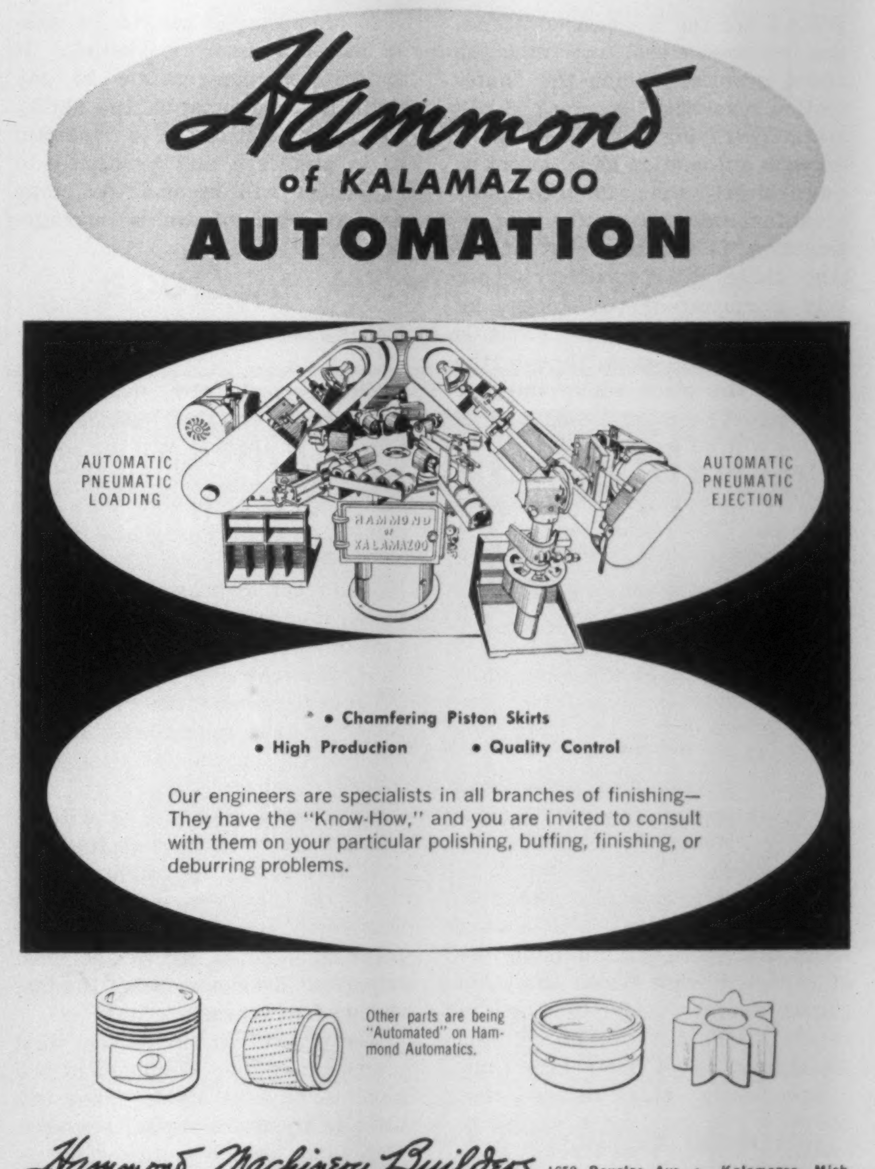
Hughes Aircraft Co.—Eight-page bulletin describes line of silicon junction diodes. Specifications and characteristics of subminiature devices are given. Diodes are fusion sealed in glass and have an ambient operating temperature range of —80 to 200 C. Bulletin includes illustrations of diodes.

Circle No. 82 on Reply Card

Electronic Timer

Ferrara Inc.—Instrument designed for interval, delayed action, repeat cycle and two-sequence timing is the subject of two-page data sheet. Electronic timer features long tube life, initiation by momentary or sustained contact and compact construction. Data sheet includes photograph of timer, power requirements, control diagrams, mounting details and price list.

Circle No. 83 on Reply Card



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AUTOMATION abstracts

THE AUTOMATION CHALLENGE TO MANAGEMENT

By PETER F. DRUCKER
New York University
New York, N. Y.

WHAT are the business problems, the economic problems and the social problems which the "automation revolution" creates? I will start by saying that our experiences in automation have taught us quite clearly that the technology of automation, no matter how interesting, is not the most important thing. Automation is not only a matter of technology, let alone of machines. Its focus is not the plant—even though the plant is the place where the new machines to run and control machines will be most visible.

Automation means above all an entirely new way to manage a business. The reason for this is a very simple one. Automation shifts the focus of business risk. Whatever automation may actually mean, it will certainly mean one thing: Production will have to be kept fairly stable at a fairly predictable rate of capacity for a fairly long time.

It is not true that automation means greater uniformity of products. On the contrary, it will mean in most manufacturing industries much greater diversity and flexibility. Automation will always mean that there is a minimum rate of capacity below which the plant cannot operate. And this rate of capacity will have to be set and maintained for a fairly long time.

Specifically this means that business can no longer adjust to economic fluctuations the way business has always adjusted to them—by changing the rate of production. Production will have to be kept fairly stable over a predetermined period. Therefore, the risk of business has to be taken increasingly by marketing. It is not an exaggeration to say that under automation the ability to create a market, to maintain it, to predict it and constantly to expand it will become the hinge around which business management will turn.

Labor Fixed Cost

The second new demand of automation on the business enterprise is that it will make labor into a capital resource of the business and labor cost into something suspiciously like a fixed cost. Historically we have always looked upon labor as a current cost which fluctuates directly with volume of production. Let me say that this historical view which still underlines economic theory has already become outmoded. If you analyze the actual operation of a modern business, you will find that a very large part of its labor force would have to be kept on the payroll as long as the plant or the office are kept open at all. Indeed this rapid rise in the break-even point of labor is one of the most important developments of the last twenty-five years.

There is a second reason why, under automation, employment will have to be kept stable, labor will have to become a capital resource. The labor which automation requires is not unskilled and untrained labor. Indeed it is not even manually skilled labor. It is labor with a tremendously high knowledge of theory and method, educated rather than skilled.

In practically every business, at least for the next twenty-five years, the only way to produce this labor is by producing it oneself within the business. And once this labor force has been brought into being, it will represent much too great an investment of time, effort and capital for any business to disperse it except under the threat of financial disaster. We can therefore confidently expect automation to demand that we learn to operate with very stable employment, and that we learn to take the fluctuations of the economic world somewhere else rather than by laying off and putting on workers.

Changing Ownership

This will create a real problem requiring great imagination, great competence and great innovation in financial planning. We will be caught between two quite contradictory forces. On the one hand, ownership of our capital is moving rapidly into the hands of institutional investors, the investment trusts, pension funds and insurance companies. These institutional investors need a predictable and fairly stable return on their investments. On the other hand the need to maintain stable production and stable employment means a need for greater flexibility in profits and dividends on the part of the business enterprise.

This conflict of two demands on management's financial planning will have to be resolved by putting our financial thinking and our financial planning on a long-range basis. We will have to get rid of the fiction of annual profit—a tired fiction anyhow—and will have to learn to think of return in terms of the normal cycle of our industry—three years, five years, in some industries ten years. Over such a longer period, we will indeed be able to plan for predictable returns.

We will, however, also have to educate our new owners, the institutional investors, to think in these terms. Here lies one of the major impacts of automation and one of the major challenges to management.

The Unemployment Question

Let me turn now to the social impact of automation. First, of course, the question whether it will produce unemployment.

You may say that we do not yet have a fully automated plant let alone a fully automated business so that we can really only speculate about the effect of automation on employment. But we have plenty of examples of industries—and of companies within industries—which have come so close to automation as to show us quite clearly what the social impact is like. And uniformly, automation has not meant a sharp cut in employment; the one and only exception, perhaps, are large clerical operations where automation may produce sharp cuts in the number of people needed. But in manufacturing there is no such effect. I would even wonder whether there is any cut in employment at all—to the point where I would strongly advise anybody against going into automation simply because it seems to promise reduction in labor costs.

What happens is a tremendous shift in the nature of the jobs. The production worker does indeed disappear. But there will be many hundreds, if not thousands and eventually millions, of new kinds of workers behind the scenes—engineers to design the new machines, technicians to program them and to control them, high grade machinists with a fair knowledge of basic engineering and mathematics to maintain them, and so forth. What automation actually means is a tremendous upgrading of labor.

But while the employment picture is actually a very good one,

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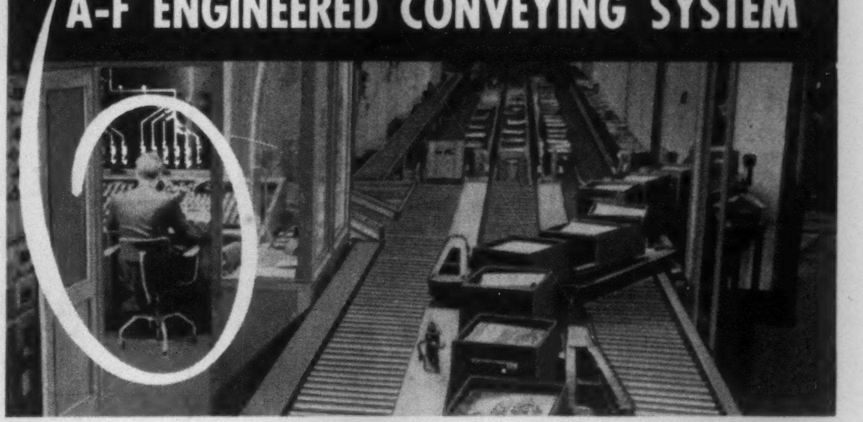
1 MAN ALONE OPERATES PLANTWIDE A-F ENGINEERED CONVEYING SYSTEM



Just 1 man, sitting at the control panel, shown above, automatically controls the *starting* and *stopping* of *all* or *part* of this A-F Engineered Completely Co-ordinated Conveying System. He also routes and switches "trains" of cases on 5 A-F Conveyor lines to 2 groups of loading docks . . . Cases are automatically counted as they're being moved . . . Visible and audible signals prevent traffic jams. Before you order any type of conveyor, better write us. We'll be glad to submit an estimate.

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this tremendous shift will certainly create major problems. In the first place, where will the new learned workers come from? There is only one source that they can come from—the present workers. We will have to train a whole generation over the next twenty-five years for new jobs, new demands, and new opportunities. And the toughest job of all will undoubtedly be the training of supervisors partly because supervisors are by and large the oldest group in industry today.

But there is also a tremendous challenge in this transition period. Certainly, the shift, while eventually beneficial to the employee, can be very painful. In many cases it will mean a shift to new and different work. In a good many cases it will mean a shift out of the present place of employment to another. In other words, there will be considerable dislocation. It is therefore a major challenge to business management to plan in advance on the retraining and on the re-placement of the human resources—to decide in advance what people will be needed under automation, where they will be needed, what they will be doing, and what people will have to leave the plant, for whom employment will have to be found on the outside. This is not primarily a demand of social responsibility; it is a demand of good business management.

Fortunately, the shift to automation is not a fast one. It takes a good many years for any plant or office to move from the present basis to that of automation. There is plenty of time to plan for the people without whom automation could not succeed. For let me emphasize this: Automation is not run by machines; it is run by people.

Automation, instead of replacing man by machine, actually depends on the knowledge, the competence, the responsibility and the motivation of people to an infinitely greater extent than any method of production we ever had. And the success of the transition to automation depends first and foremost on the quality of the planning of the human resources.

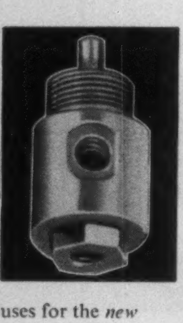
Incentive Through Challenge

There is yet another social consequence. Under automation the individual employe will largely have to work on his own. It will simply not be possible to supervise him in the sense of somebody standing over him, telling him what to do, when to do it and, in an emergency, doing the job for him.

Management, therefore will have to learn how to motivate people. Let me say that this would have been one of our major challenges anyhow. During the last twenty-five years American management has lost the one motivating force that it traditionally relied upon: Motivation by fear. This is the one certain meaning of the unionization of the American worker. I happen to believe that fear is a very poor way to motivate.

Motivation has to be supplied and to supply it is the responsibility of leadership of management. We are not quite without some knowledge and insight into motivation. We know the major factors.

How to **STAKE** and **BEND WITH YOUR THUMB!**



NEW! Clippard 3-Way Miniature Air Valve MAV-3

One of the hundreds of time and work saving uses for the *new* CLIPPARD Miniature 3-Way Normally Closed Air Valve is shown above. Jig is constructed so that a force of 75 lbs. is exerted on work by a 1" air cylinder (operating at 100 psi) when manual push-button is pressed. Stem travel of new MAV-3 Valve is 1/16" with overtravel of 1/32". Valve will handle up to 150 psi. Roller Cam-follower Head and a complete line of miniature Air Cylinders, Manifolds, Fittings and Accessories also available for that new automatic, or semiautomatic project you are now developing. Write, today, for details, catalogue sheet and prices.

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One of them is placement. We know that a man is motivated better if he is placed right, that is, if he is on a job that he can do and wants to do. We also know that placement is not something that one can do when a man comes in the plant for his first job. It requires both a knowledge of the man by his supervisor and a knowledge of work done by the man. In other words, it requires time. And we know that placement cannot be done once and for all. People change and with their change comes development and growth. The jobs they are best fitted for change also. We have to learn to consider placement as a continual job, one that is never done, one that has to be thought through every few years for everybody in the business, whether a manager, a professional, a technician, a supervisor or a rank and file worker.

Secondly, we know that high demands must be made of people. We do not respond to low demands. People want, need and demand that much be expected of them. They do not think highly of their own work unless their boss, their management, their fellow workers also think highly of it—and this means until high demands are made of them.

I recognize that this is directly counter to the gospel of industrial engineering as it has been preached or perhaps as it has been misunderstood these last twenty or thirty years. Instead of trying to set up jobs that are engineered so that the average man can turn out average work, we will have to learn to set up jobs so that the right man can do exceptional work. And we will have to learn not only to place accordingly but to encourage and reward accordingly. Under automation there are no more average men in our employ. There will be only key people, and unless they behave like key people we will surely be in trouble.

Good Management the Key

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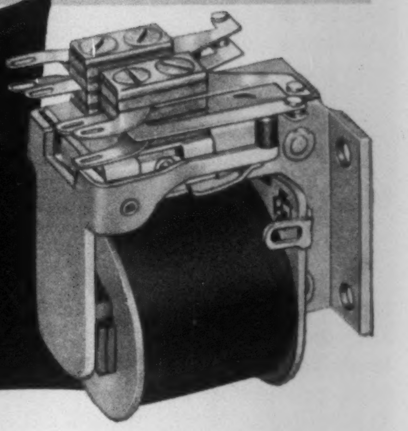

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a new product or a new productive process causes. That is, it should not mean more than localized and shortlived disturbance. However, management will have to do a very good job of managing, and especially planning human resources as part of planning the transition to automation.

At the same time, automation should make possible considerably greater social stability. Indeed it should force us to make stable the two areas which, traditionally have been both cause and effect of the greatest economic and social instability—employment and capital investment. In that respect automation, long-range, should mean not only more production but also a stable economy and society.

From a paper entitled, "The Impact of Automation on Business Enterprise, Economy and Society" presented at the midyear meeting of the American Petroleum Institute's Division of Refining in St. Louis, May 1955.

MACHINE TOOLS AUTOMATED

By F. R. SWANSON
Sundstrand Machine Tool Co.
Rockford, Ill.

NO DESIGNER who sits down and outlines the features he intends to incorporate in the design of a production machine tool today will neglect to consider the possibility of applying automation.

We might classify the progress of automation into three stages. In the early use of automatic work handling for machine tools, it was customary for the manufacturer to purchase a standard machine and design a work-handling device that would meet his needs. Because no thought had been given to apply such a device when the machine was designed, it usually reulted in a very cumbersome and unreliable device.

In the second stage, single-unit machines were designed incorporating their own handling devices. Automation on this type of machine was very satisfactory from the standpoint of operation, but it required an operator to position the work on the receiving station and usually a helper to remove the work and push it along a conveyor to next machine in the line.

We are now in the third stage where machines must be designed to operate as fully automatic units in an automatic factory. A machine tool now may be required to receive the work from the preceding machine, process the work through the necessary operations, free the work of chips, automatically gage, reject out-of-size work, stop machine, reset or insert sharpened tools and deliver the work part to the succeeding machine in the line.

From the foregoing, it is apparent that the machine tool has advanced from a comparatively simple machine, controlled by an operator to a highly automatic machine that should perform its operation continuously as reliably and with as little attention as an automatic watch.

Automation today is a basic engineering science. To design a machine tool today requires the close co-operation of a group of engineers with imagination, engineering knowledge, and trained in the various phases of machine-tool elements. The engineer must be flexible. His thinking must be in terms of equipment requiring the comparatively wide tolerances of conveyors, to the exacting precision of spindles, fixtures, and tools that will perform operations on a production basis, yet equal the accuracy of work produced in the tool room. It may clarify the subject if we discuss how automation influences the engineer's problem in the design of some machine elements.

The Basic Machine

Considering the design of a standard single-unit machine to which automation may be applied, thought should be given to the machine base to provide ample room for chip conveyors. Machine ways should be either heat-treated or nonmetallic, protected from chips and automatically lubricated to provide continuous operation with a minimum amount of attention. The base also should be designed in such a manner that it will lend itself to the application of automatic work-handling devices.

In a multiple-station machine, the base is usually designed to receive a stationary fixture having chip channels that will allow the chips to flow freely into a chip conveyor in the foundation. The automatic work-handling equipment is tailored to fit into the base and fixture as a unit.

The various stations usually have sliding heads on wing bases. These bases should be equipped with heat-treated or nonmetallic ways, protected from chips and automatically lubricated from a central lubricating system. When lubrication is automatic, there is a tendency on the part of the maintenance men to neglect periodic inspection of the points of lubrication. Therefore, it is important to provide a signal in case of any failure in the system.

A very important point to consider in a multistation machine is accessibility. The machine units should be spaced far enough apart to provide room for changing cutting tools and for the setup men to observe the cutting tools in operation.

Grouping of operations and number of units in each section of the machine is usually determined by the customer's process men. However, similar operations such as drilling, milling, boring, etc., can be grouped in a section. This makes possible shorter sections with a stacking station between each section so the work can be stacked or shuttled past a section that may be down for repair or tool change.

Electrical Controls

Regardless of the type of automatic machine, whether a single machine or line of self-loading machines, certain basic requirements are necessary for good control. As the control becomes more complex, the means by which these are met must change. These requirements are as follows:

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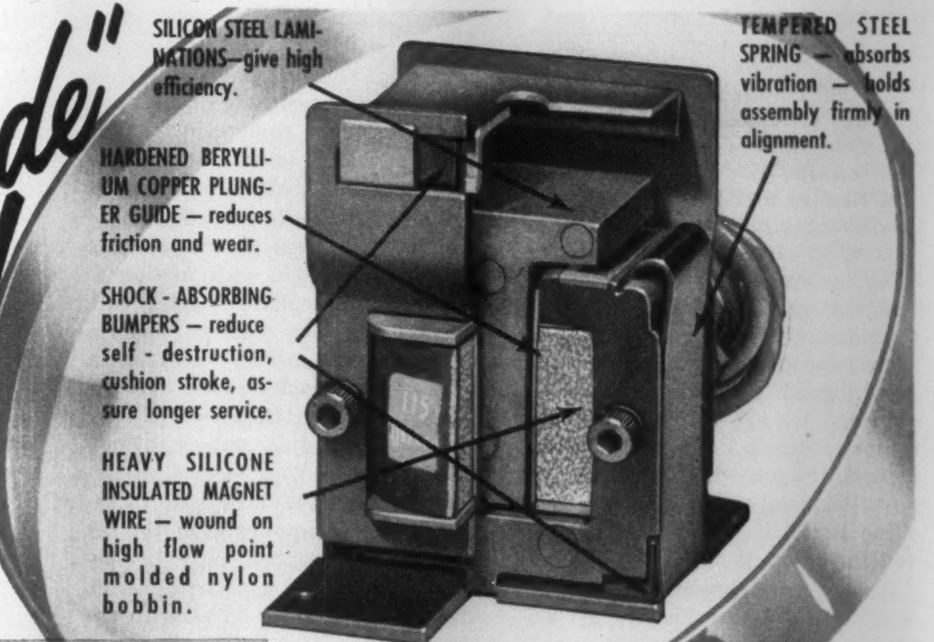
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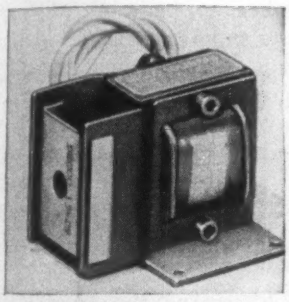
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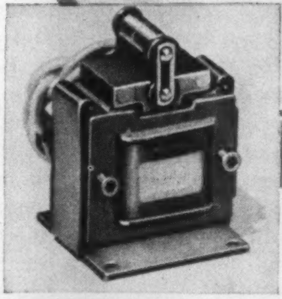
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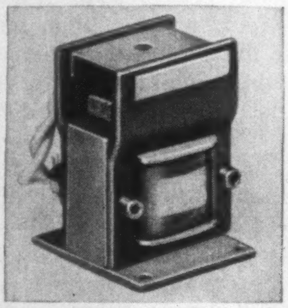
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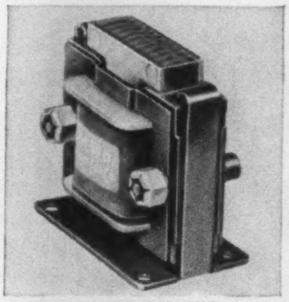
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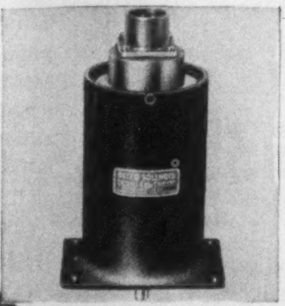
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The proper application of NMTBA or JIC Standards insures compliance with the foregoing to a considerable extent. Beyond this point, good electrical control is obtained by the proper choice of components and a carefully designed circuit—both of which must be compatible with the machine itself, the man who runs it and its physical surroundings.

Safety for personnel has two aspects: (1) Avoidance of exposure to high voltage; (2) avoidance of an unintentional movement of any part of the machine. Avoiding electrical shock is a matter of a mechanically good wiring job particularly on the machine to prevent damage to piping and terminal boxes by trucks, personnel, etc.

The failure of an electrical component must not cause a false operation of the machine but rather stop the movement depending upon this particular component. This becomes more important as the automation of machines increases.

One way to alleviate this is to design the control circuits so that as far as possible each motion is a result of energizing a relay coil, solenoid valve or starter. Then a wiring or coil failure results in a part of the machine not moving. Mechanically latched relays are useful also in this respect. They may be used to energize a hydraulic solenoid valve and maintain fixture clamping even though part of the control may be deenergized due to a failure. Also, latched relays may be used to determine direction of a head or shuttle travel. Then after a loss of voltage due to failure, the cycle may be resumed and the relay "remembers" which direction to send the shuttle or head.

Life of components is important regardless of the kind of machine being controlled. In automation lines, it is more important because a failure is usually harder to locate. Also if one machine in the line is down, the whole line may be without work.

As greater numbers of machine tools are grouped together to function in unison without operators attention, the number of limit switches, relays, solenoid valves, etc., required increases tremendously. All these items being mechanical in nature are subject to failure, causing increased maintenance and loss of production. Much thought and development are being directed toward the replacement of these items with electronic eyes, vacuum or thyratron tubes, transistors and many forms of electronic devices.

Increasing automation causes maintenance to be more difficult and at the same time requires that it be done more quickly. The time required to replace a part is usually very small compared to that required to locate the failure, so most maintenance aids are directed at finding which component has failed. Pilot lights quickly indicate what part of a machine has failed to operate, which fixture has failed to operate, which head has failed to run, etc. Perhaps a head fails to feed, a pilot light indicates the fixture has not clamped, and another indicates that the part is not properly positoned for clamping. By the proper use of pilot lights, the specific part of a machine that is the basic cause of failure can be determined quickly.

The operator then must be able to run all or any group of machines he desires in either manual or completely automatic control. This can be done if two adjacent groups of machines are designed so that their mechanical work-handling mechanisms cannot possibly interfere, allowing each to run independently of the other.

Hydraulic Controls

Hydraulic circuit design has undergone considerable change during the evolution of automation. Today the designer must consider hydraulic installations with a new set of standards in mind. To the uninitiated, the most apparent

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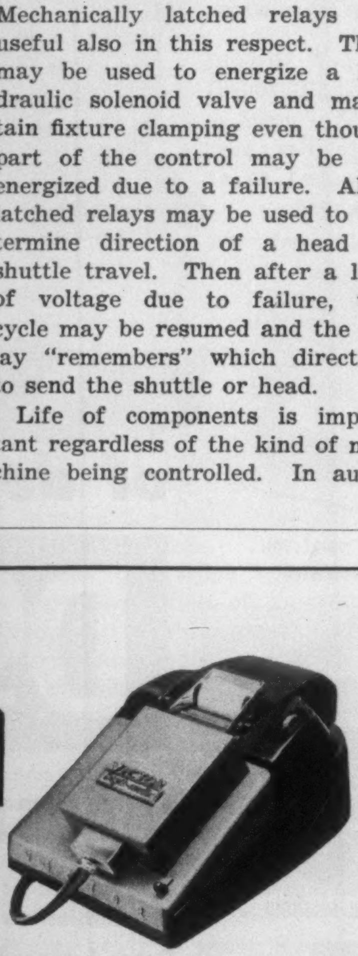


change is in appearance. A manufacturer, in a competitive high-production industry, is less interested in a machine that is a thing of beauty, than he is in a machine that will give trouble-free operation at minimum maintenance cost.

It is an accepted practice now to mount the pump and operating valves on an individual reservoir, separate from the machine and driven by its own electric motor. On a multistation machine, these individual units are placed in line along one side of the machine or placed on a catwalk above the machine in proximity to the electrical panels. The oil-level gage and pressure gage indicating filter condition face outward so the oiler can check at a glance while walking past the units. Gasket-mounted valves can be replaced in a matter of minutes without disturbing piping. Gage ports throughout the circuit allow circuit trouble-shooting with a minimum of effort.

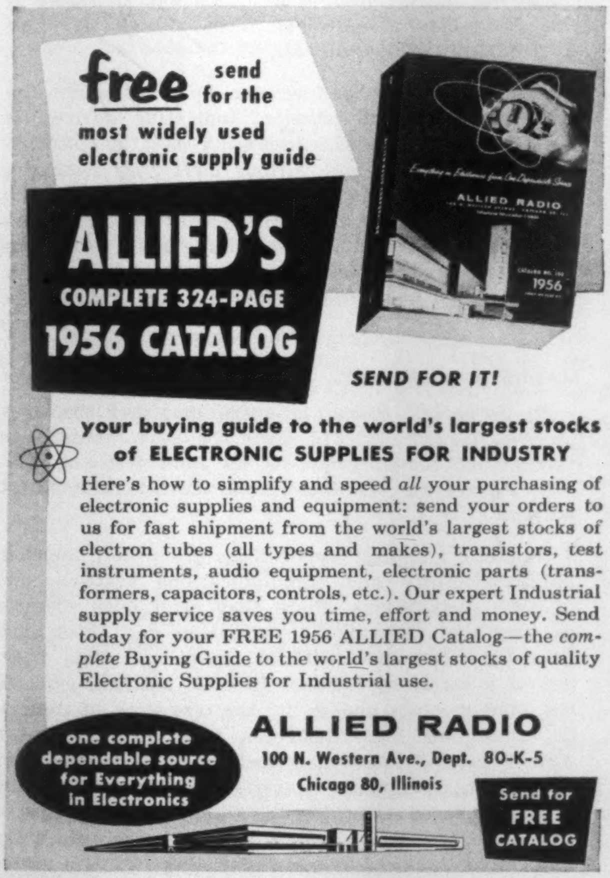
The onset of automation also has produced marked changes in circuit design. The necessity of complete electrical interlocking to insure proper sequencing of related movements has practically eliminated the pilot-operated circuit. The use of sequence valves to pressure sequence a series of operations has been replaced with electrically controlled directional valves to isolate the control of each motion.

Much has been done to answer the familiar objection to hydraulics—the common garden variety of leaks. It was expected that dry seal pipe threads would be the answer, but they left much to be desired. Work is being done now on pipe threads using dissimilar male and female taper, and the experimental results look very promising. By using steel tubing, modern tube fittings and a leak-proof thread, the objectionable leak will be a thing of the past.

It would be very beneficial to the user if suppliers of hydraulic components would standardize mounting dimension which would facilitate quick replacements with stock units regardless of make.

Although great strides have been made in designing machine tools and accessories for automation, there are still unlimited possibilities for the future. Perhaps the most eminent single item that may affect future designs will be the increased application of electronic computers, digital converters and various feedback systems to the controls of automation in all its phases such as the machine tool itself, work-handling, accumulation of gaging data, production output, programming, etc. As designers of machine tools, we are a part of a small industry, but it gives us great satisfaction to be called upon to eliminate the human drudgery of repetitive operations, the physical exertion of machine operators and the very important task of producing an improved product at less cost which will continue to elevate our economic life.

From a paper entitled, "Influence of Automation on Machine Tool Design" presented at the Annual Meeting of ASME in New York, Nov.-Dec. 1954.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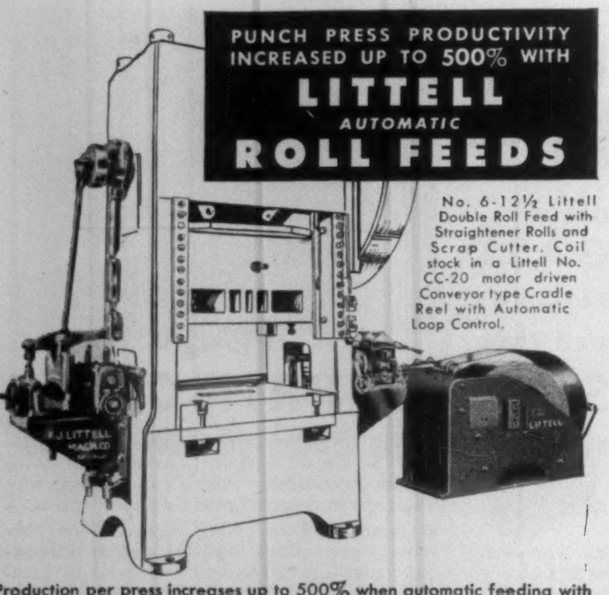
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By Walter R. Evans, controls group leader, Electromechanical Engineering Dept., North American Aviation Inc.; 282 pages, 6 by 9 inches, illustrated, clothbound, published by McGraw-Hill Book Co. Inc., New York; available from AUTOMATION; $7.00 *postpaid.*

Calculation procedures, including the root-locus method developed by the author, are presented to aid those concerned with solutions to control-system problems. Sample problems range from change in speed of a motor under suddenly applied voltage to combined effect of roll and yaw motions of an airplane. Summary statements are given at the beginning of each topic for quick reference by the reader. This work is published as part of an electrical and electronic engineering series.

ELECTRONIC MEASURING INSTRUMENTS

By E. H. W. Banner, consulting engineer; 395 pages, 5¾ by 8¾ inches, illustrated, clothbound, published by the Macmillan Co., New York; available from AUTOMATION; $8.50 *postpaid.*

Material compiled and written by an English engineer covers characteristics of indicating devices for electronic instruments, components used in electronic measuring devices, and various electronic measuring systems. Among the instruments discussed are valve devices, cathode-ray instruments, photoelectric units, rectifiers, and radiation thickness gages. Additional related devices discussed include counters, strain gages, various other transducers, and electrical instruments.

MAGNETIC AMPLIFIERS

By Herbert F. Storm, magnetic amplifier specialist, General Electric Co.; 545 pages, 5¾ by 9 inches, illustrated, clothbound, published by John Wiley & Sons Inc., New York; available from AUTOMATION; $13.50 *postpaid.*

Magnetic amplifier applications are widely found in industry, utility and communications systems, and military installations where they offer such features as long life, resistance to vibration and shock, and immediate operation without warm-up. This book, one of a series by General Electric authors, explains the fundamentals underlying the operation of magnetic amplifiers and illustrates their principal uses. Among related areas discussed are modern theory of magnetism, magnetic materials, magnetic testing, manufacture of saturable reactors, and properties of metallic rectifiers. Because magnetic amplifiers are often used in closed-loop systems, they are also represented in servo-block diagram form, suitable for immediate integration into a servo system. A section covering nomenclature and abbreviations, and a bibliography are included, as well as useful conversion factors.

Association Publications

INDUSTRIAL ENGINEERING TERMINOLOGY

Paperbound, 48 *pages,* 5¼ *by* 7¾ *inches; available from the American Society of Mechanical Engineers,* 29 *West* 39*th St., New York* 18, *N. Y.*: $1.50.

This publication is the American Society of Mechanical Engineers Standard No. 106. It presents standard definitions of industrial engineering terms in alphabetical dictionary form. Definitions given were developed by an industrial engineer, reviewed and revised with the participation of several committees including terminology committees in Australia, Canada, South Africa, and the United Kingdom.

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Paperbound, 123 *pages,* 6 *by* 9 *inches; available from American Management Association,* 330 *West* 42*nd St., New York* 36, *N. Y.;* $1.75.

This booklet is a compilation of papers presented in April 1955. These papers describe a variety of packaging materials, and consider characteristics, manufacture, advantages and uses. The materials discussed include: Aluminum foil; glassine and greaseproof papers; label and box-wrap papers; boxboard; films of acetate, cellophane, polythylene, Saran, polystyrene, Pliofilm, vinyls, and Mylar; foam plastics from phenolics, polystyrene, vinyl and urethane.

Government Publications

Infrared: A Library of Congress Bibliography. *Report PB* 111643 *by Library of Congress,* 374 *pages, available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $3.00.

This comprehensive bibliography refers to literature on infrared radiation published from 1935 to 1951. The classification proceeds from infrared theory and general infrared-optical properties, through the various elements and components of infrared equipment, infrared spectroscopy and photography, to its various applications in science, the arts and industry.

Application of Transistors to Electronic Counting Equipment. *Report PB* 111610 *by Army Signal Corps,* 77 *pages, illustrated, available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $2.00.

Results of the studies of transistor switching circuits, decade counter development, and control circuit development, leading to design of a frequency meter are given. This electronic counter uses plug-in construction and transistors instead of vacuum tubes. Details of design and construction of the meter, and conclusions on transistor application are included.

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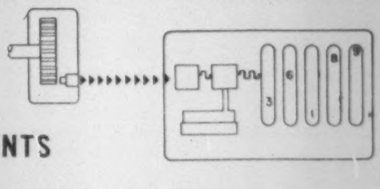

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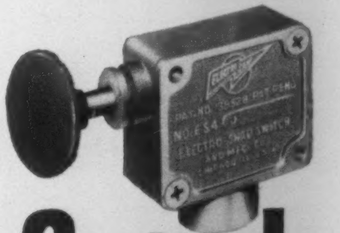

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